Bulletin No. 152

SEA STARS

(Echinodermata: Asteroidea) of arctic North America

by E. H. Grainger

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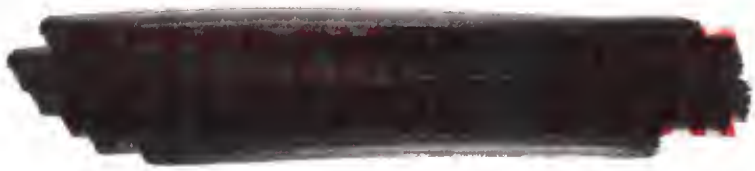

SEA STARS

(ECHINODERMATA: ASTEROIDEA)

OF ARCTIC NORTH AMERICA

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By E. H. Grainger

Fisheries Research Board of Canada
Arctic Biological Station, Ste. Anne de Bellevue, Que.

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ABSTRACT

Twenty-four species of sea stars are reported from northern North American waters between the Strait of Belle Isle and Point Barrow, Alaska. A key for identification and morphological descriptions of all the recorded species and several of probable occurrence in the region are included. Data are given on geographical distribution and on depth, substrate, temperature, and salinity conditions. Arctic–subarctic waters surrounding the Arctic Ocean are shown on the basis or sea star distribution to comprise two major zoogeographical regions: Atlantic–arctic and Pacific. Arctic North America east of about 120°W is included in the Atlantic–arctic region. Farther west the fauna is primarily Pacific.

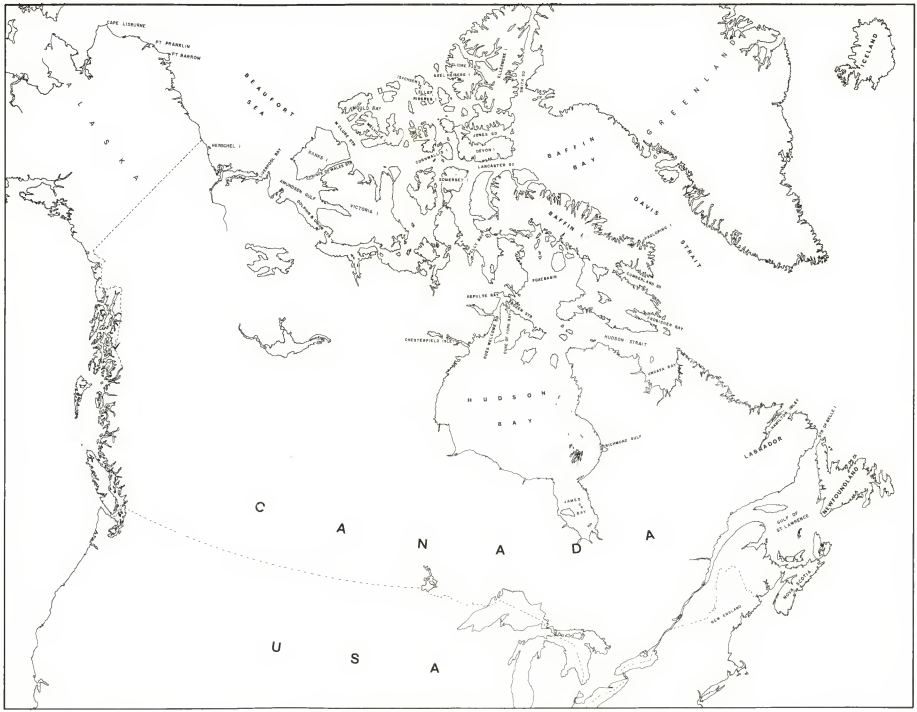


FIG. 1. Map showing geographical locations referred to in the text.

INTRODUCTION

The region considered here comprises northern North American waters between the Strait of Belle Isle (southern Labrador) and Point Barrow (Alaska) and includes inland bays and passages among the arctic islands as well as coastal waters of the Beaufort Sea and of the seas separating Canada and Greenland (Fig. 1). The known sea star fauna of this region consists at present of 24 species. Another five species at least, recorded from adjacent areas, may reasonably be expected also to occur here.

Published accounts of 21 former collections from the present region are listed below (Table I). Species names are given according to common contemporary usage, and names as they appear in the original works, when different from contemporary ones, are placed in parentheses after the present form.

The material examined for treatment in this paper consists for the most part of collections made by the M. V. *Calanus* of the Fisheries Research Board of Canada between 1953 and 1961 in the eastern Canadian arctic. In addition, collections made by the M. V. *Salvelinus* (Fisheries Research Board of Canada) from 1960 to 1963 in the western Canadian arctic, by Mr S. D. MacDonald of the National Museum of Canada at several locations on the islands of the high arctic, by Dr D. V. Ellis on Baffin Island, by Dr W. F. Black in Pelly Bay, and by Mr A. H. Lawrie in the Beaufort Sea were examined, and a small collection was made by the author with the Polar Continental Shelf Project on Ellef Ringnes Island in 1960. Finally, collections made by land-based field parties of the Fisheries Research Board of Canada on Banks, Victoria, Somerset, Cornwallis, Axel Heiberg, and Ellesmere islands in 1962 have contributed to fill in large areas previously blank on the distribution maps.

KEY TO THE ASTEROIDEA OF NORTHERN NORTH AMERICA

A key for the identification of sea stars is given below. It is hoped that the key will permit those who are not primarily students of the Asteroidea to identify northern North American specimens with a minimum of difficulty. It is emphasized that use of the key alone is not necessarily sufficient to achieve correct identification; the key is simply a guide to point the user towards the correct species name. All tentative identifications should be checked against descriptions given and referred to in the species section. While an attempt has been made to include all species of the region in the key, there will almost certainly be species found which are not contained in it, and for which other works than this will be required for identification.

TABLE I. Summary of former sea star records from northern North America.

Author	Location	Species listed
Sabine, 1824	Melville Island	*Ctenodiscus crispatus* (*Asterias polaris*)
Forbes, 1852	Cornwallis Island	*C. crispatus* (*C. polaris*), *Solaster papposus* (*S. papposa*), *Leptasterias groenlandica* (*Urasterias violacea*)
Walker, 1862	Somerset Island	*Solaster endeca*, *L. groenlandica* (*U. violacea*)
Packard, 1863	South Labrador	*S. papposus* (*S. papposa*), *Henricia ?eschrichti* (*Cribrella oculata*), *Leptasterias polaris* (*Asteracanthion polaris*)
Packard, 1867	South Labrador	*S. papposus* (*S. papposa*), *S. endeca*, *H. ?eschrichti* (*C. oculata*), *L. groenlandica* (*Asterias groenlandicus*), *L. polaris* (*Asteracanthion polaris*)
Duncan and Sladen, 1877, 1878, 1881	East Ellesmere Island	*Pteraster militaris*, *Lophaster furcifer*, *S. papposus* (*Crossaster*), *Pedicellaster typicus* (*P. palaeocrystallus*), *Stephanasterias albula* (*Stichaster albulus*), *L. groenlandica* (*Asteracanthion groenlandicum*)
Verrill, 1879	Cumberland Sound	*S. albula*, *L. groenlandica*, *Leptasterias mülleri* (probably incorrectly named)
Bush, 1884	Labrador	*S. papposus* (*Crossaster*), *H. ?eschrichti* (*Cribrella sanguinolenta*), *Leptasterias littoralis*, *L. polaris* (*Asterias*)
Whiteaves, 1884	Port Burwell, Ungava Bay	*L. polaris* (*Asterias*)
Murdoch, 1885	Point Barrow region, Alaska	*S. papposus* (*Crossaster*), *S. endeca*, *Henricia* sp. (*Cribrella sanguinolenta*), *L. polaris* (*L. polaris acervata*), *L. arctica*
Pfeffer, 1886	Cumberland Sound	*L. polaris* (*Asterias*), *L. groenlandica* (*Asterias*)
Rankin, 1901	Labrador	*L. polaris*
Grieg, 1907	Jones Sound	*S. papposus*, *L. furcifer* (*Solaster*), *P. militaris*, *S. albula* (*Stichaster albulus*), *L. groenlandica* (*Asterias mülleri groenlandica*), *Icasterias panopla* (*Asterias*)
Clark, 1920	Alaska to Dolphin and Union Strait, and east arctic	*S. papposus* (*Crossaster*), *S. endeca*, *C. crispatus*, *S. albula*, *Urasterias lincki*, *L. groenlandica* (*Ctenasterias cribraria*), *L. polaris* (*Asterias acervata borealis*), *Leptasterias arctica*
Clark, 1922	Hudson Bay	*S. papposus* (*Crossaster*), *U. lincki*, *L. groenlandica*, *L. polaris* (*Asterias acervata borealis*)
Mortensen, 1932	Western Baffin Bay and Davis Strait	*C. crispatus*, *Bathybiaster vexillifer*, *Leptychaster arcticus*, *Pontaster tenuispinus*, *Poraniomorpha bidens*, *Pteraster militaris*, *Hymenaster pellucidus*, *L. furcifer*, *S. papposus*, *P. typicus*, *S. albula*, *I. panopla*, *L. groenlandica*, *L. polaris*

(*Continued*)

TABLE I. Summary of former sea star records from northern North America. — (*Concluded*)

Author	Location	Species listed
Clark, 1936	Eastern arctic	*S. papposus* (*Crossaster*), *H. ?eschrichti* (*H. sanguinolenta*), *P. militaris*, *S. albula*, *L. groenlandica*, *L. polaris*
Clark, 1937	Hudson Bay	*C. crispatus*, *Poraniomorpha tumida tuberculata*, *H. ?eschrichti* (*H. sanguinolenta*), *S. endeca*, *S. papposus* (*Crossaster*), *L. furcifer*, *Pteraster obscurus*, *P. militaris*, *U. lincki*, *L. polaris*, *Leptasterias mülleri* (probably incorrectly named)
MacGinitie, 1955	Point Barrow, Alaska	*S. papposus*, *S. endeca*, *Henricia* sp. (*H. sanguinolenta*), *L. groenlandica*, *L. polaris*, *L. arctica*
Grainger, 1955	Eastern arctic	*C. crispatus*, *P. militaris*, *L. furcifer*, *S. papposus*, *S. endeca*, *H. eschrichti*, *S. albula*, *U. lincki*, *L. groenlandica*, *L. polaris* (*Asterias*)
Grainger, 1964	Labrador	*C. crispatus*, *P. tumida tuberculata*, *S. papposus*, *P. militaris*, *P. pulvillus*, *H. eschrichti*, *Henricia scabrior*, *S. albula*, *U. lincki*, *L. groenlandica*, *L. polaris*

The principal source for the construction of this key was Djakonov (1950). Other general sea star keys of value for the region treated here are those of Fisher (1911, 1928, 1930), Verrill (1914), Shorygin (1948), and Mortensen (1927). Other works include brief keys either to a few species only from a limited geographical area (e.g. Clark (1904); Coe (1912)), or to restricted taxonomic groups. One of the most useful among the latter is on the genus *Henricia* in Heding (1935).

For the purpose of clarifying morphological terms and features referred to both in the key and in descriptions of the species given below, Fig. 2–46 are included to show selected structural features. A glossary of terms is placed at the end of the paper.

1(10,37) Marginal plates, usually several times larger than adjacent plates, forming a conspicuously wide lateral margin to the disc and rays (Fig. 2). Supramarginal and inframarginal plates frequently in contact with one another along the full length of the plates. Aboral skeleton of closely set paxilliform plates crowned by spines or tubercles (Fig. 2, 3). No crossed pedicellariae. Usually 5 rays.

PHANEROZONIA

2(7) Tube-feet conical, without flat sucking discs.

3(4) Cribiform organs between marginal plates. Tube-foot ampullae single. Supramarginal plates, conspicuously larger than the inframarginals, each with an obvious spine near the aboral margin, these spines forming a conspicuous "fence" between the lateral and aboral surfaces of the rays (Fig. 2, 4). Inframarginal plates with a single row of spines (Fig. 4). Rays short (R:r about 1.6:1 to 3:1), rounded terminally.

Ctenodiscus crispatus (Retzius)

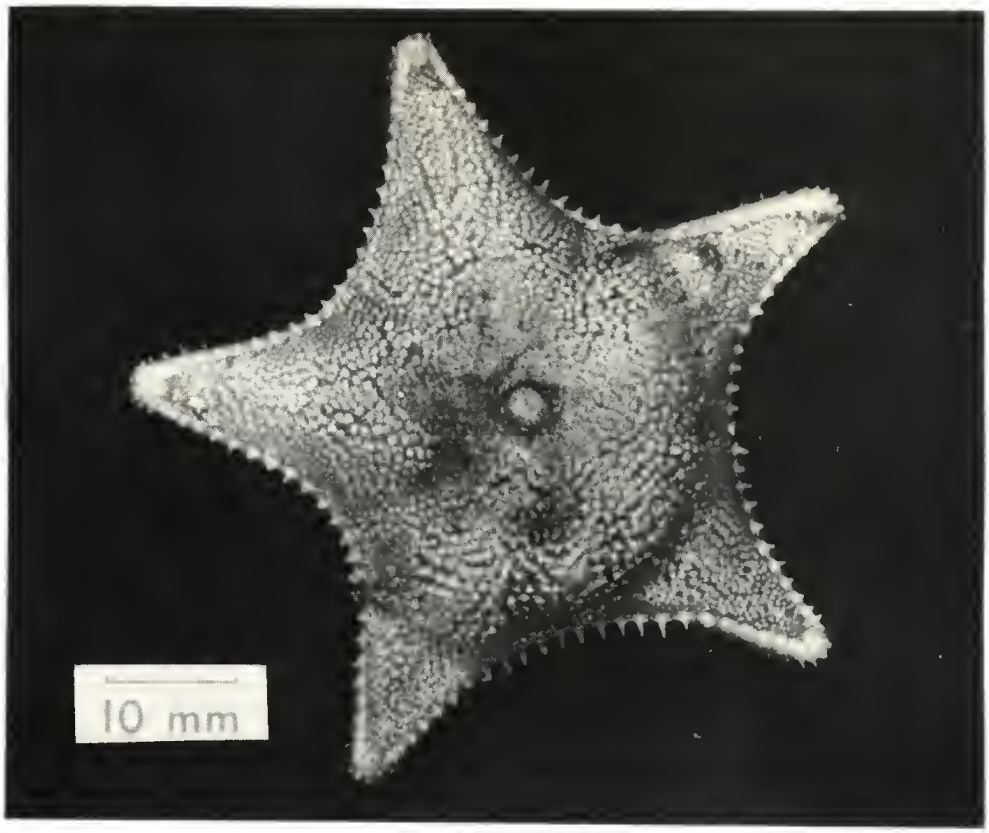


FIG. 2. *Ctenodiscus crispatus.* Note the row of supramarginal spines separating the lateral and aboral (top) surfaces, and the closely spaced aboral paxillae.

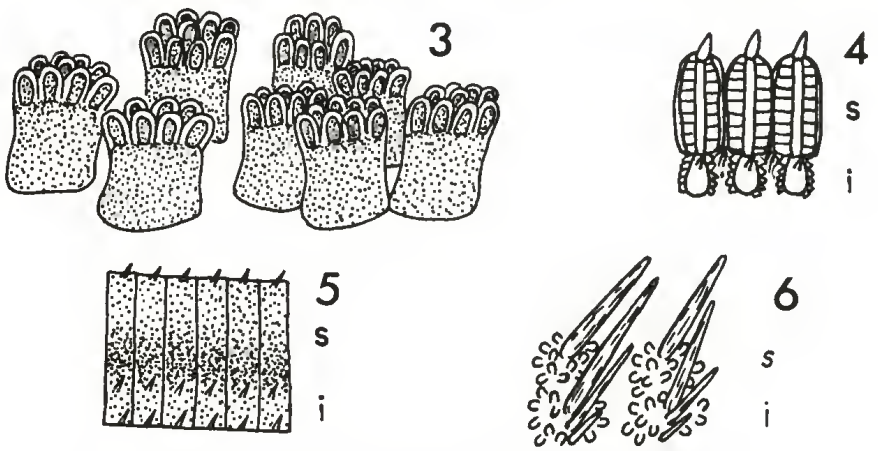


FIG. 3. *Ctenodiscus crispatus*, aboral paxillae.

FIG. 4. *Ctenodiscus crispatus*, supramarginal (s) and inframarginal (i) plates and spines.

FIG. 5. *Bathybiaster vexillifer*, supramarginal (s) and inframarginal (i) plates and spines (from Danielssen and Koren, 1884).

FIG. 6. *Pontaster tenuispinus*, inframarginal plate and spines (i) and supramarginal plate and spine (s) (from Düben and Koren, 1846).

4(3) Cribiform organs absent. Tube-foot ampullae double. Supramarginal plates not conspicuously larger than inframarginals.

5(6) Supramarginal plates, not conspicuously different in size from the inframarginals, each with a relatively small spine (Fig. 5). Inframarginal plates with 1–4 rows of small spines, numbers decreasing from base to tip of ray (Fig. 5). Rays long (R:r about 4:1 to 6:1), slender, pointed terminally.

Bathybiaster vexillifer W. Thomson

6(5) Supramarginal plates clearly smaller than the inframarginals and both without differentiated spines. Rays relatively short (R:r about 2:1 to 3.2:1), tapering to rather blunt ends.

Leptychaster arcticus (M. Sars)

7(2) Tube-feet cylindrical, with flat sucking discs.

8(9) Supramarginal and inframarginal plates distinct and bearing obvious sharp spines, one on each plate considerably longer than the adjacent spines and forming 2 conspicuous longitudinal rows (Fig. 6). Paired muscle bands from proximal adambulacral plates to the tip of the ray. Rays long (R:r about 3:1 to 7:1), slender, pointed.

Pontaster tenuispinus (Düben and Koren)

9(8) Supramarginal and inframarginal plates almost concealed by a thick cover, without conspicuous spines. No muscle bands as above. Rays short (R:r about 1.5:1 to 2.5:1), rounded.

Poraniomorpha tumida (Stuxberg)

(The form *tuberculata* Danielssen and Koren differs from *tumida* s.s. in having relatively longer rays, single circular knobs on the aboral surface of the disc and rays (Fig. 7), and usually only a single row of spines (rather than 2 or 3 rows) on the adambulacral plates.)

10(1,37) Marginal plates not several times larger than adjacent plates, and not forming a conspicuously wide lateral margin to the disc and rays. Supramarginal and inframarginal plates usually not in contact with each other along their full length, but only by means of plate lobes. Aboral skeleton of more or less reticulated plates, either simply bearing individual spines, groups of spines (Fig. 8), or showing paxilla-like features of erect columns topped by spine clusters (Fig. 9–11). No crossed pedicellariae. Tube-feet (except in *Diplopteraster*) in 2 rows. Often more than 5 rays.

SPINULOSA

11(20) Marginal and aboral plates covered by a supradorsal membrane.

12(19) Adambulacral spines in transverse, webbed rows (Fig. 12).

13(14) Adambulacral plates with 2 kinds of webbed rows of spines, the more conspicuous (4–5 spines) alternating with the less conspicuous (3–4 spines) (Fig. 12). Tube-feet in 4 rows.

Diplopteraster multipes (M. Sars)

14(13) Adambulacral plates with 1 kind of webbed row of spines. Tube-feet in 2 rows.

15(18) Rays usually 5.

16(17) R:r more than 1.9:1 (to about 2.5:1). Paxilliform plates with low pedicels, little higher than broad, each with 3–5 slender spines several times longer than the pedicel (Fig. 9).

Pteraster militaris (O. F. Müller)

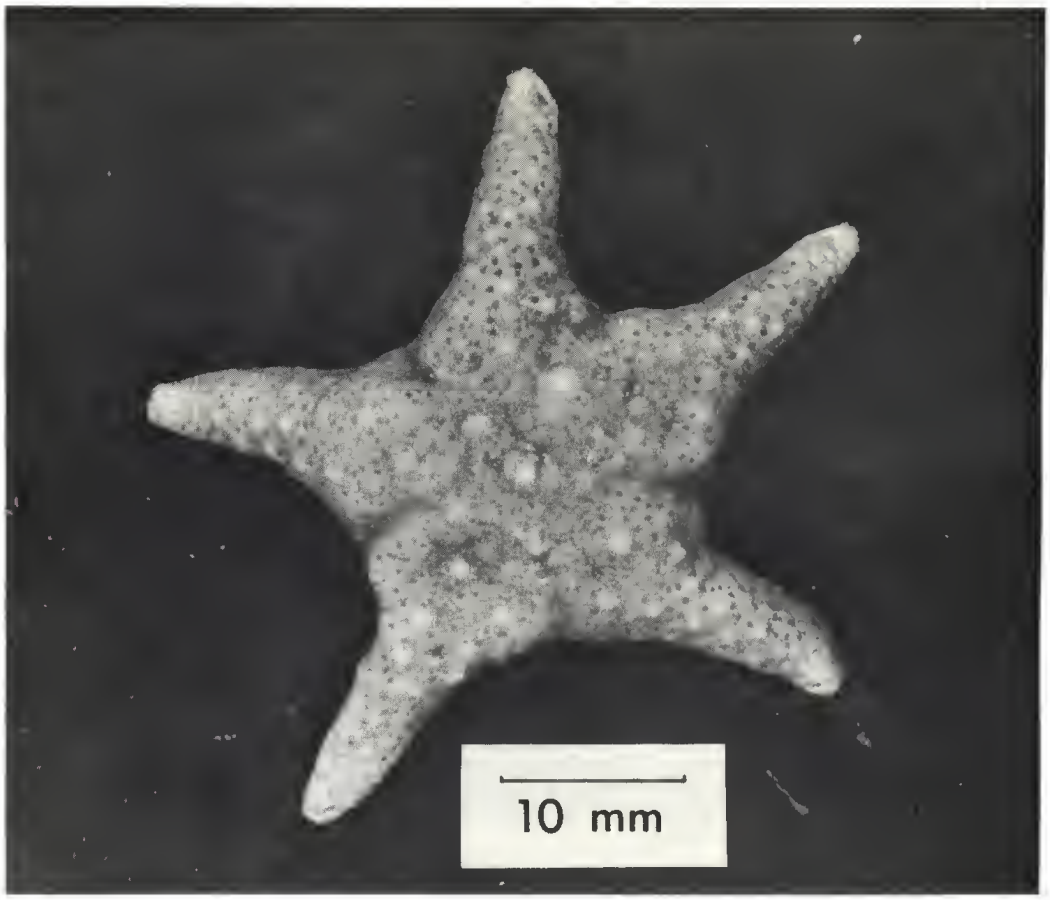


FIG. 7. *Poraniomorpha tumida tuberculata*. Note the circular knobs on the aboral surface.

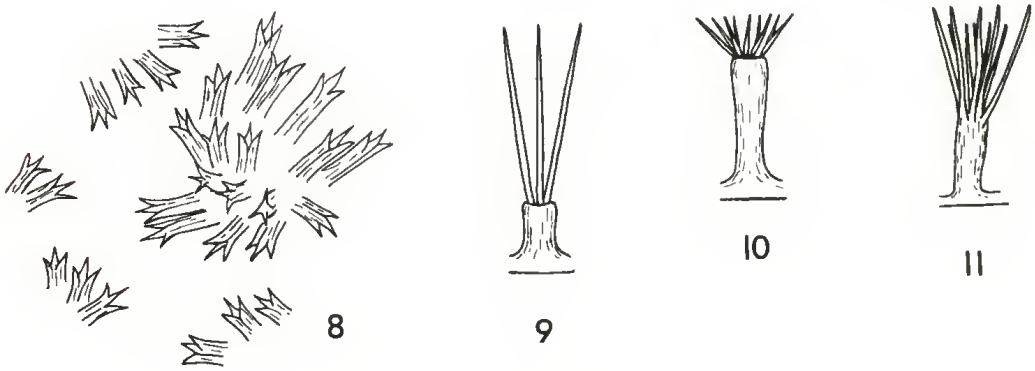
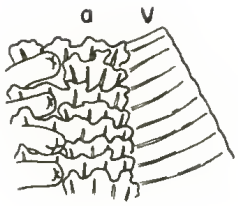


FIG. 8. *Henricia eschrichti*, aboral spine group.

FIG. 9. *Pteraster militaris*, aboral ray spines emerging from paxilla plate pedicel.

FIG. 10. *Pteraster pulvillus*, aboral ray spines.

FIG. 11. *Pteraster obscurus*, aboral ray spines.



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13

14

FIG. 12. *Diplopteraster multipes*, transverse webbed adambulacral spine rows (a) and longitudinal ventrolateral membrane (v) (from Sars, 1877).

FIG. 13. *Lophaster furcifer*, supramarginal (s) and inframarginal (i) plates and spines.

FIG. 14. *Solaster papposus*, supramarginal (s) and inframarginal (i) spines.

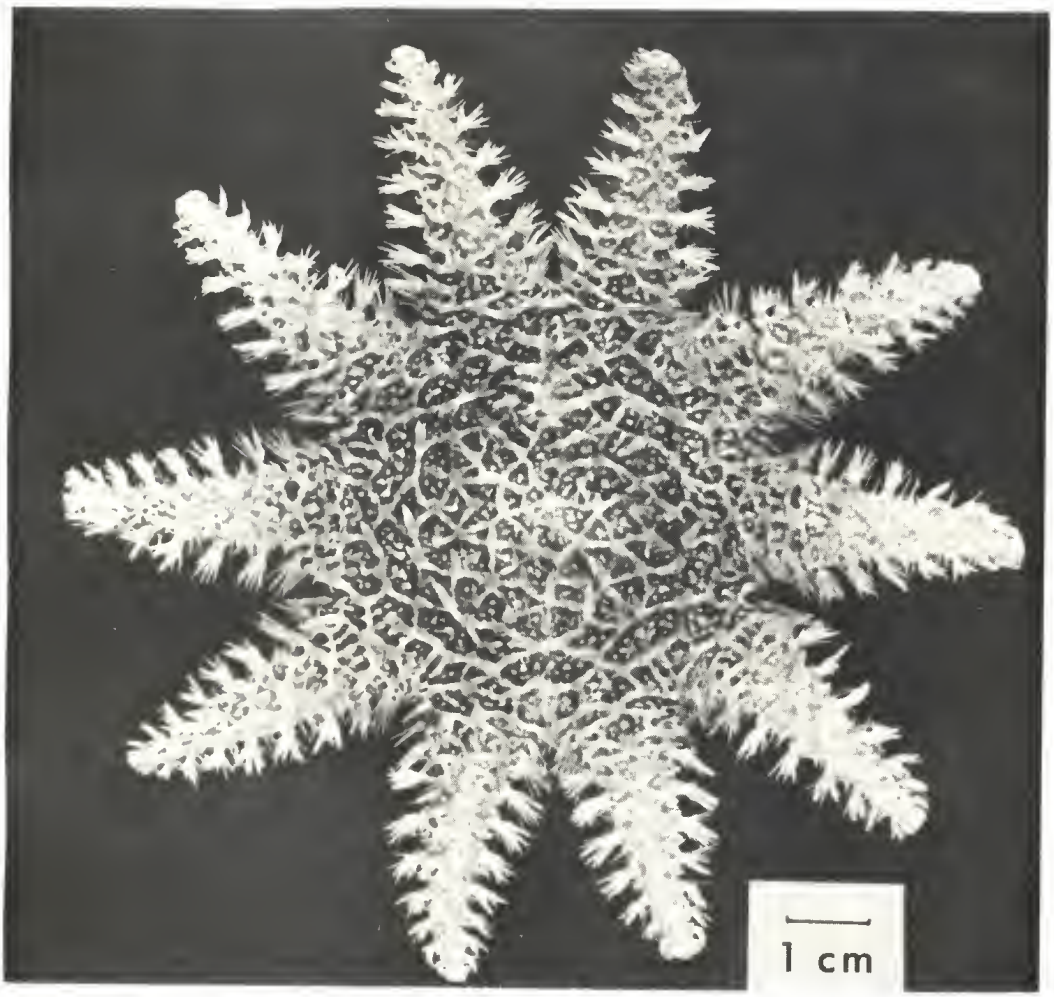

FIG. 15. *Solaster papposus*. Note the conspicuous inframarginal spine groups bordering the rays, and the open mesh and large papular areas of the aboral surface of the disc.

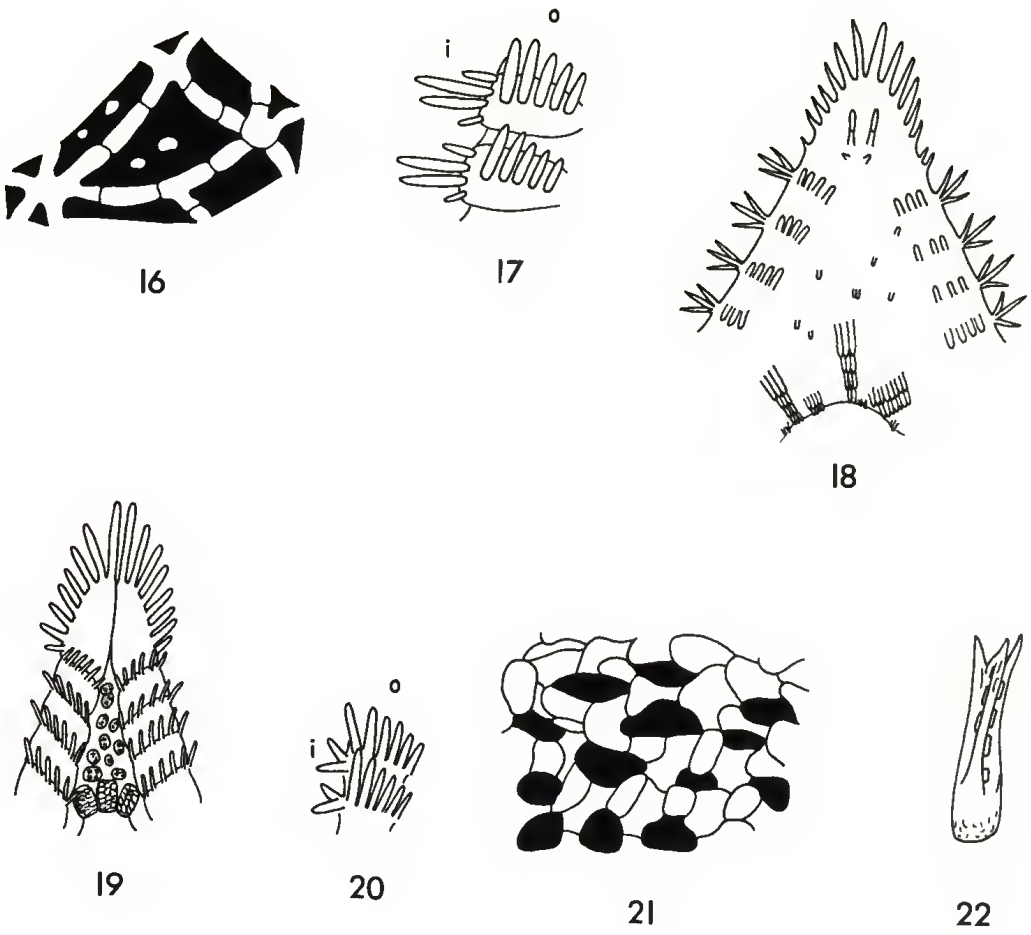

FIG. 16. *Solaster papposus*, aboral plate rows enclosing dark papular areas.

FIG. 17. *Solaster syrtensis*, inner (i) and outer (o) adambulacral spines.

FIG. 18. *Solaster glacialis*, oral interradial area enclosed by oral plates (top) and adambulacral plates of adjacent rays (from Danielssen and Koren, 1884).

FIG. 19. *Solaster syrtensis*, oral interradial area.

FIG. 20. *Solaster endeca*, inner (i) and outer (o) adambulacral spines.

FIG. 21. *Henricia eschrichti*, aboral ray plates.

FIG. 22. *Henricia eschrichti*, aboral spine.

17(16) R:r less than 1.9:1 (to about 1.3:1). Paxilliform plates with high pedicels, about 4 times as high as broad, each with about 6–15 slender diverging spines shorter than the pedicel (Fig. 10).

Pteraster pulvillus M. Sars

18(15) Rays usually 6 or more. R:r about 1.4:1 to 1.7:1. Paxilliform plates with pedicels about 2–3 times as high as broad, each with about 6–8 peripheral spines, and about 4–8 shorter, more slender central spines. Long spines a little longer than, short spines a little shorter than, the pedicel (Fig. 11).

Pteraster obscurus (Perrier)

19(12) Adambulacral spines not in transverse webbed rows. Large nidamental cavity below well-developed supradorsal membrane, pierced centrally by a conspicuous opening.

Hymenaster pellucidus W. Thomson

20(11) Marginal plates, if present, visible, with spine groups in 1 or 2 series. No supradorsal membrane present.

21(32) Marginal plates with at least 1 row of spine groups noticeably higher than the adjacent dorsolateral spines. Adambulacral spine rows in 2 series, one transverse and one parallel to the groove.

22(23) Marginal spine groups in 2 conspicuous, nearly equal rows (Fig. 13). 5 rays.

Lophaster furcifer (Düben and Koren)

23(22) Marginal spine groups in 1 or 2 rows, with only inframarginals especially well developed, supramarginals smaller (Fig. 14). More than 5 rays.

24(27) One conspicuous row of marginal spine groups, the inframarginals; supramarginals almost indistinguishable from aboral spines (Fig. 15).

25(26) Aboral skeleton of narrow bars forming an open irregular network (Fig. 15, 16), meshes larger than skeletal parts.

Solaster papposus (L.)

26(25) Aboral skelton of imbricated plates forming a close-meshed surface, meshes smaller than skeletal parts.

Solaster squamatus Döderlein

27(24) Two conspicuous rows of marginal spine groups, the inframarginals the larger, but the supramarginals clearly distinguishable from aboral spines.

28(31) Inner adambulacral spines (parallel to the groove) about equal in length to the outer adambulacrals (right angles to the groove) (Fig. 17).

29(30) Oral interradii without spine clusters and only rarely with single spines (Fig. 18).

Solaster glacialis Danielssen and Koren

30(29) Oral interradii with well-developed spine clusters (Fig. 19).

Solaster syrtensis Verrill

31(28) Inner adambulacral spines (parallel to the groove) conspicuously shorter than the outer adambulacrals (right angles to the groove) (Fig. 20).

Solaster endeca (L.)

32(21) Marginal plates, if present (and other lateral plates) with spine groups not noticeably higher than adjacent dorsolateral spines. Adambulacral spine rows in a single series, all transverse.

FIG. 23. *Henricia eschrichti.* Note the large evenly placed marginal plates.

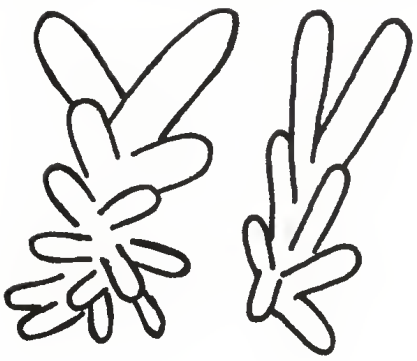

FIG. 24. *Henricia eschrichti*, adambulacral spines (from Grainger, 1955).

33(36) Aboral plates (Fig. 21) each with about 4–40 naked spines (Fig. 8). Spines with usually 3–4 longitudinal ridges extended distally to form a crown of sharp diverging points (Fig. 22). Marginal plates large, in even rows in close contact with adjacent rows (Fig. 23).

34(35) Adambulacral plates with usually 2 (sometimes 3) transverse rows of spines, the largest (usually 2) near the groove (Fig. 24). Aboral ray plates forming small irregular meshes, papular areas much smaller than plates (Fig. 21, 25). R:r about 3:1 to 4:1.

Henricia eschrichti (Müller and Troschel)

35(34) Adambulacral plates with about 25–30 spines, irregularly arranged and of similar length (Fig. 26). Aboral ray plates closely imbricated, with few extremely small papular areas (Fig. 27, 28). R:r about 3:1 to 4:1.

Henricia eschrichti laevior (Mikhaĭlovskiĭ)

36(33) Aboral plates almost always with only single membrane-covered spines, without evenly defined longitudinal ridges and with irregularly blunt distal ends (Fig. 29). Marginal plates not evident (Fig. 30). Aboral ray plates forming large irregular meshes (Fig. 30, 31). Adambulacral spines in 1 sometimes slightly irregular row, numbering about 4–7 per plate (Fig. 32). R:r about 4:1 to 6:1.

Henricia scabrior (Mikhaĭlovskiĭ)

37(1,10) Marginal plates not several times larger than adjacent plates and not forming a conspicuously wide lateral margin to the disc and rays. Superior and inferior marginals in contact only by plate lobes (Fig. 33). Carinal plates often in more or less regular longitudinal series (Fig. 34–36). Aboral skeleton of flattened reticulated plates, often elongate, 3- or 4-lobed (Fig. 36), with spines originating separately on the surface of the plates, and not paxilliform. Papulae on both aboral and oral surfaces. Both straight and crossed pedicellariae present. Tube-feet in 4 (rarely 2) rows. Rays usually 5, occasionally more numerous.

FORCIPULATA

38(39) Tube-feet in 2 rows. Mouth frame incomplete, the first pair of adambulacral plates of each ray not meeting medially.

Pedicellaster typicus M. Sars

39(38) Tube-feet in 4 rows. Mouth frame complete.

40(45) Adambulacral spines without pedicellariae. Adambulacral plates usually with not fewer than 2 spines each. Dorsolateral papular areas not conspicuously transversely elongate.

41(42) Aboral skeleton compact, close-meshed, with papular areas usually much narrower than the surrounding plates (Fig. 37). Carinals in conspicuously straight rows (Fig. 37, 38). Aboral plates with groups of up to 5 or more spines. The majority of adambulacral plates with 2 (or 3) spines in transverse rows. Five to 9 or more rays, often distinctly unequal in size (Fig. 38).

Stephanasterias albula (Stimpson)

42(41) Aboral skeleton relatively wide-meshed, with papular areas usually as wide as or wider than the surrounding plates (Fig. 34). Carinals in fairly regular rows. Aboral plates with smooth spines occurring singly. Adambulacral plates with 2 spines. Usually 5 rays, of approximately equal size.

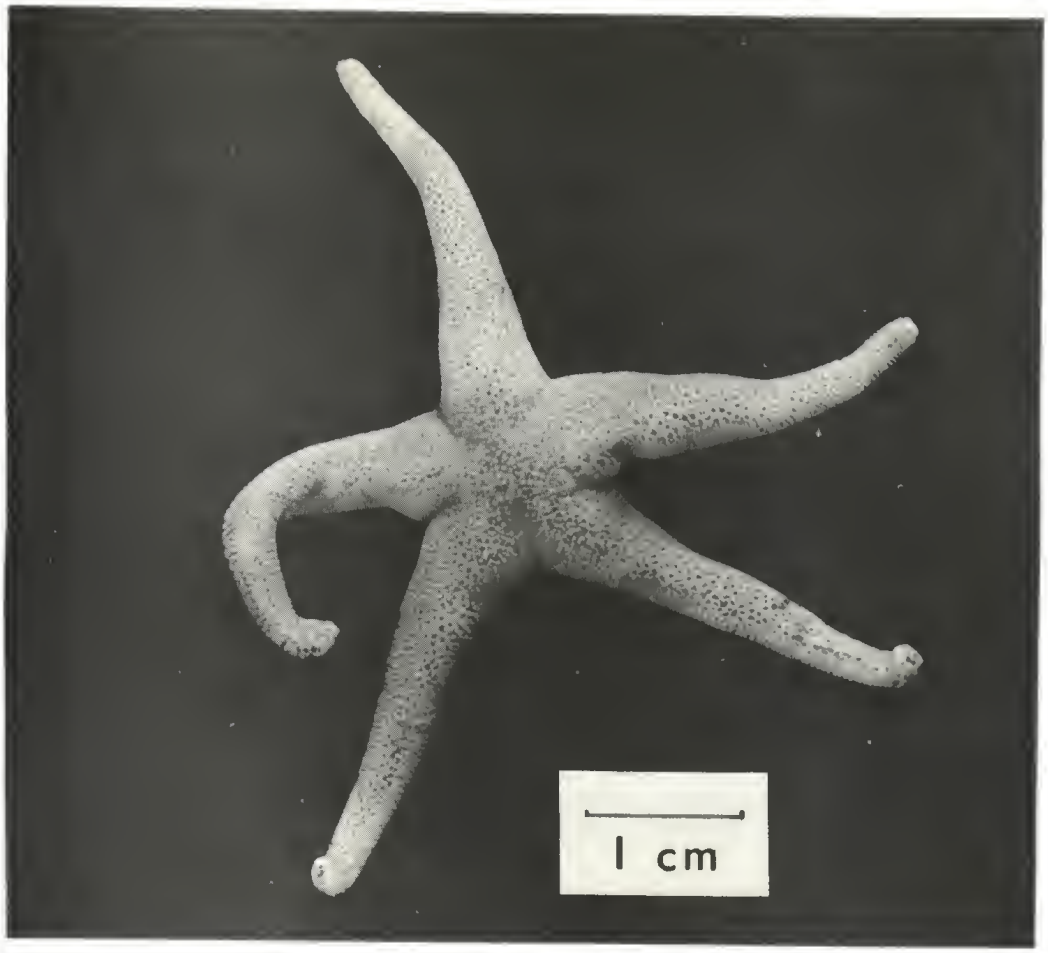

FIG. 25. *Henricia eschrichti.* Note the small irregular meshes and the small papular areas on the aboral surface of the disc and rays.

26

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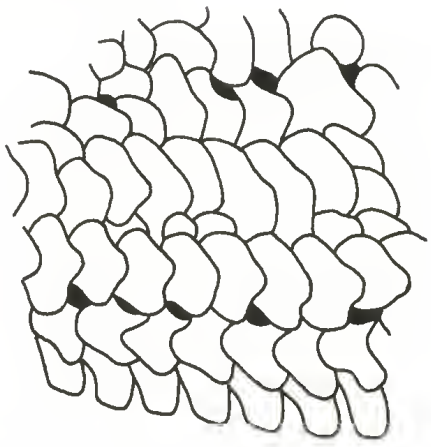


FIG. 26. *Henricia eschrichti laevior*, adambulacral spines (from Heding, 1935).

FIG. 27. *Henricia eschrichti laevior*, lateral ray plates (from Heding, 1935).

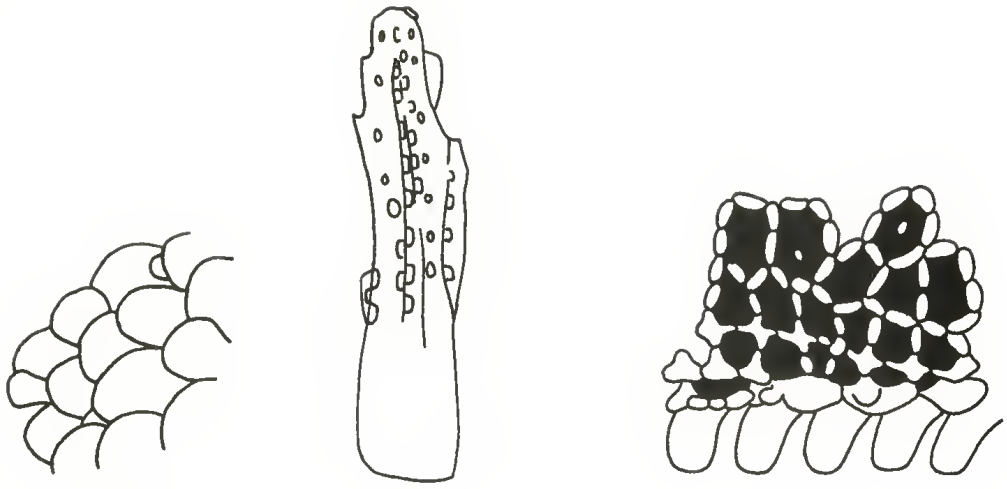


FIG. 28. *Henricia eschrichti laevior*, aboral ray plates (from Heding, 1935).

FIG. 29. *Henricia scabrior*, aboral spine.

FIG. 30. *Henricia scabrior*, lateral ray plates.

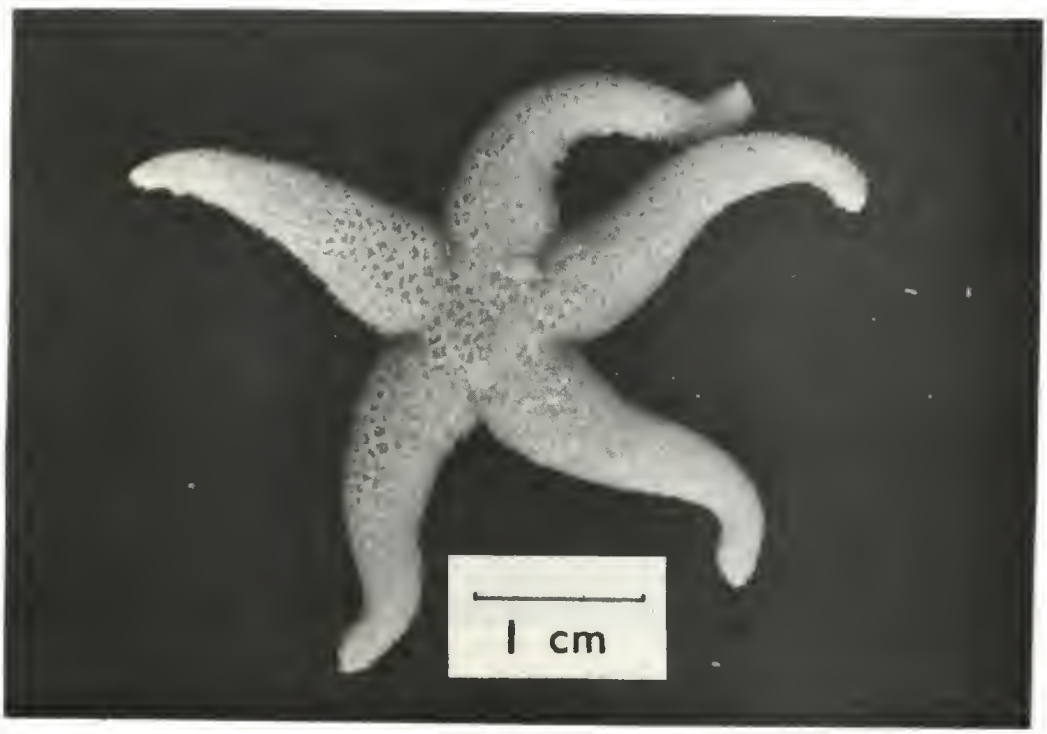
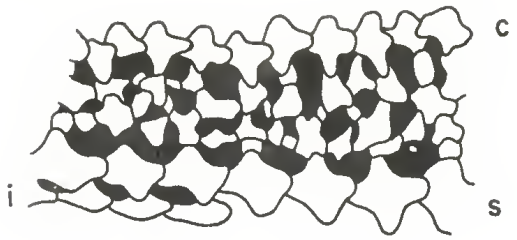


FIG. 31. *Henricia scabrior*. Note the large irregular meshes and the large papular areas on the aboral surface of the disc and rays.

32



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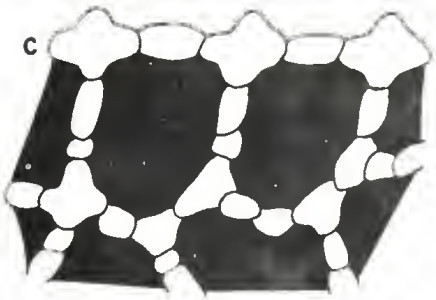

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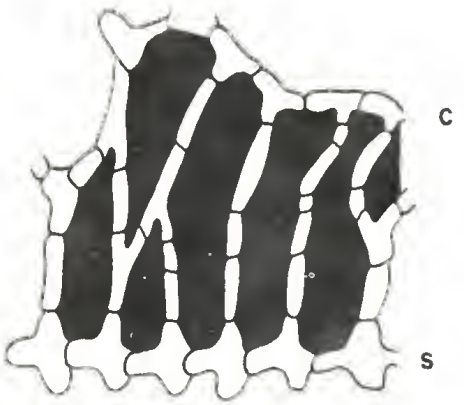

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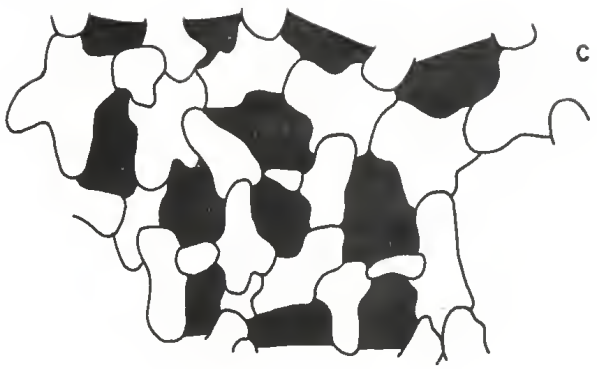

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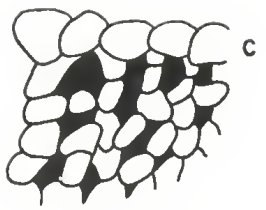


37

FIG. 32. *Henricia scabrior*, adambulacral spines.

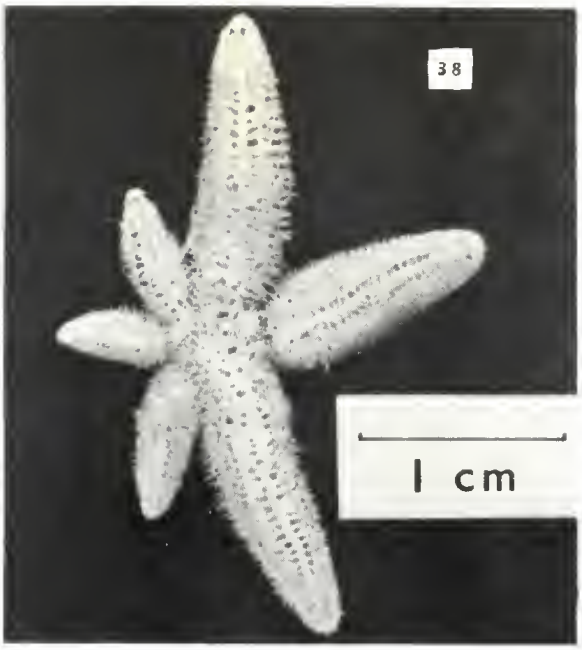
FIG. 33. *Leptasterias floccosa*, lateral ray plates (c, carinals; s, supramarginals; i, inframarginals) (from Heding, 1935).

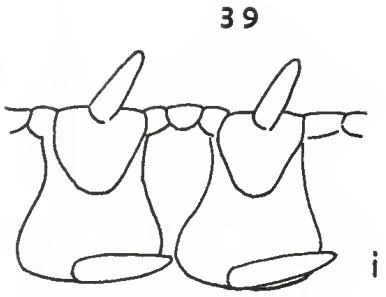
FIG. 34. *Urasterias lincki*, aboral ray plates (c, carinals).

FIG. 35. *Leptasterias groenlandica*, lateral ray plates (c, carinals; s, supramarginals) (from Grainger, 1955).

FIG. 36. *Leptasterias arctica*, aboral ray plates (c, carinals) (from Fisher, 1930).

FIG. 37. *Stephanasterias albula*, aboral ray plates (c, carinals).





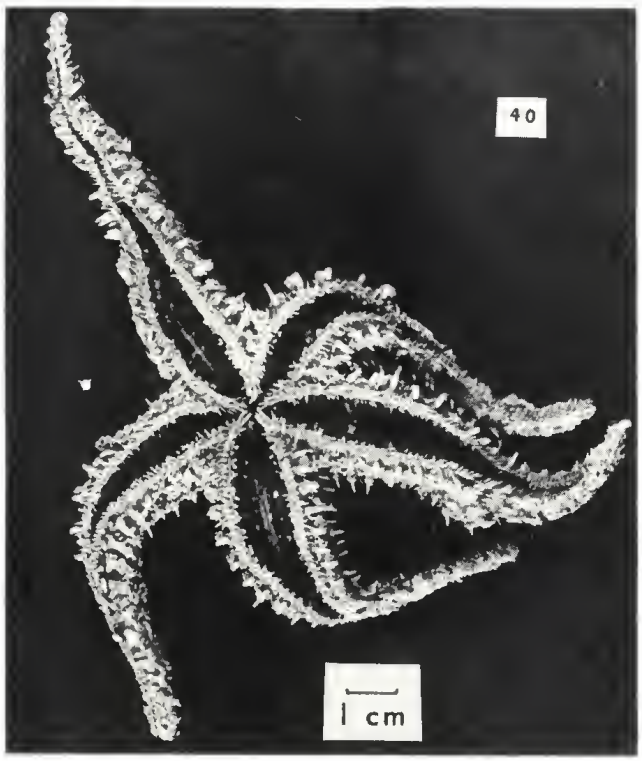


FIG. 38. *Stephanasterias albula*. Note the straight rows of carinal plates along the centre of the aboral surface of the rays, and the unequal size of the rays.

FIG. 39. *Urasterias lincki*, marginal plates and spines (i, inframarginals).

FIG. 40. *Urasterias lincki*. Note the single row of large inframarginal spines, and the clusters of pedicellariae around the spines.

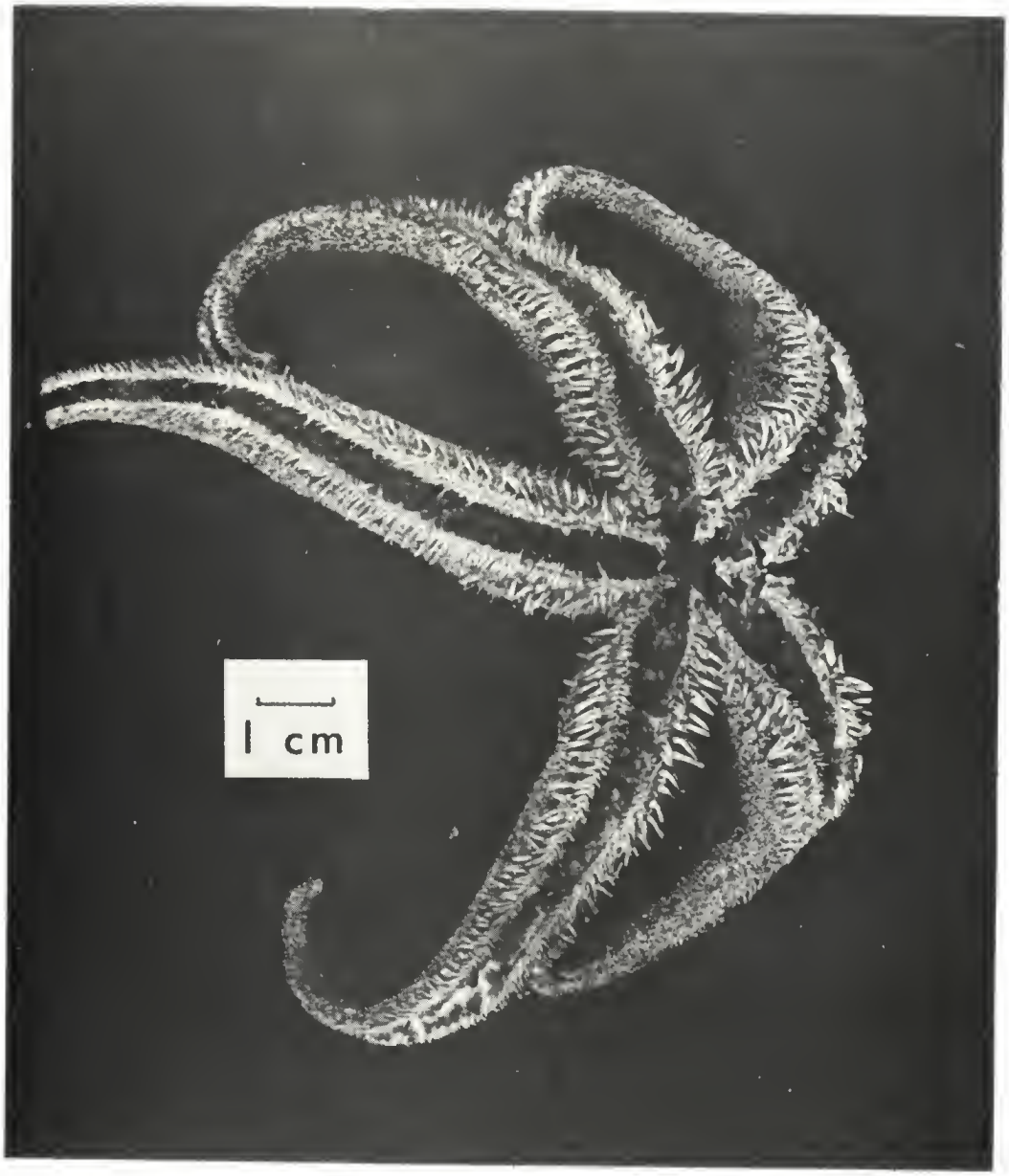


FIG. 41. *Icasterias panopla*. Note the large inframarginal spines without clusters of pedicellariae.

43(44) Inframarginal plates each with a single spine (Fig. 39, 40). Carinal spines not usually conspicuously distinguishable in size from dorsolateral spines. Conspicuous clusters of very large crossed pedicellariae surrounding the marginal spines (Fig. 40).

Urasterias lincki (Müller and Troschel)

44(43) Inframarginal plates each ordinarily with 2 spines. Carinal spines, in a single straight row, usually conspicuously larger than dorsolateral spines. No clusters of pedicellariae around marginal spines (Fig. 41).

Icasterias panopla (Stuxberg)

45(40) Adambulacral spines usually bearing clustered or single pedicellariae. Spines irregularly arranged on adambulacral plates, but showing a tendency towards an alternating pattern of 1–2 (although often as 2–2) on adjacent plates (Fig. 42).

46(51) 5 rays.

47(48) Aboral spines frequently, although not always solitary, short, bulbous, and flattened distally (Fig. 43), and arranged in no regular pattern. Papular areas in the dorsolateral skeleton generally small, not conspicuously narrow and transversely elongate, and never extending all the way from the supramarginals to the carinals (Fig. 36).

Leptasterias arctica (Murdoch)

48(47) Aboral spines often, but not always in groups, arranged either in transverse rows or scattered more or less randomly, either with no evidence of terminal expansion or with only slightly bulbous ends (Fig. 44).

49(50) Dorsolateral plates usually arranged in fairly regular transverse rows, leaving transversely elongate and usually narrow papular areas extending often from the supramarginals to the carinals (Fig. 35, 45).

Leptasterias groenlandica (Steenstrup)

50(49) Dorsolateral plates irregularly arranged, with small uneven papular areas scattered between the carinals and the supramarginals (Fig. 33).

Leptasterias floccosa (Levinsen)

51(46) 6 rays.

52(53) Aboral network close-meshed, usually with fairly large, slightly bulbous carinal and dorsolateral spines largely indistinguishable in size (Fig. 46). Spines, often forming raised groups, consisting of a larger central spine surrounded by several smaller spines, generally irregularly distributed or showing some evidence of longitudinal rows.

Leptasterias polaris (Müller and Troschel)

53(52) Aboral network close-meshed, with carinal spines very large with bulbous tips up to 2 mm in diameter and smaller dorsolateral spines. The spines, typically in groups of 2–5 of similar size, usually form evident but irregular longitudinal rows.

Leptasterias dispar Verrill

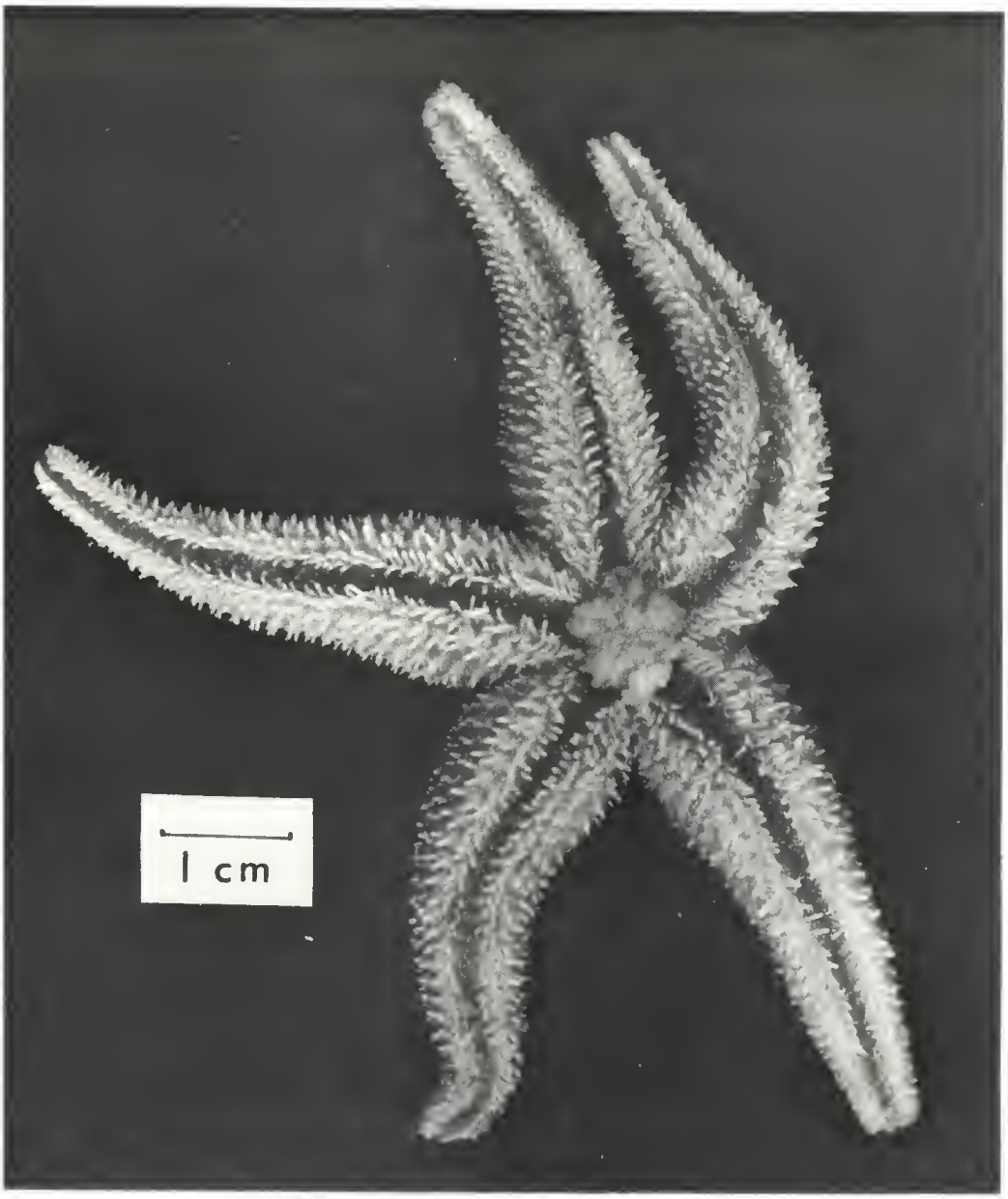


FIG. 42. *Leptasterias groenlandica*. Note the adambulacral spines bordering the ambulacral groove. The stomach of this specimen is partly evaginated.

43

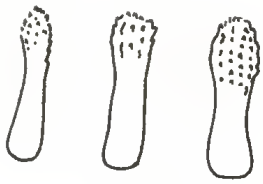


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FIG. 43. *Leptasterias arctica*, aboral spines (from Fisher, 1930).

FIG. 44. *Leptasterias floccosa*, aboral spines (carinals) (from Heding, 1935).

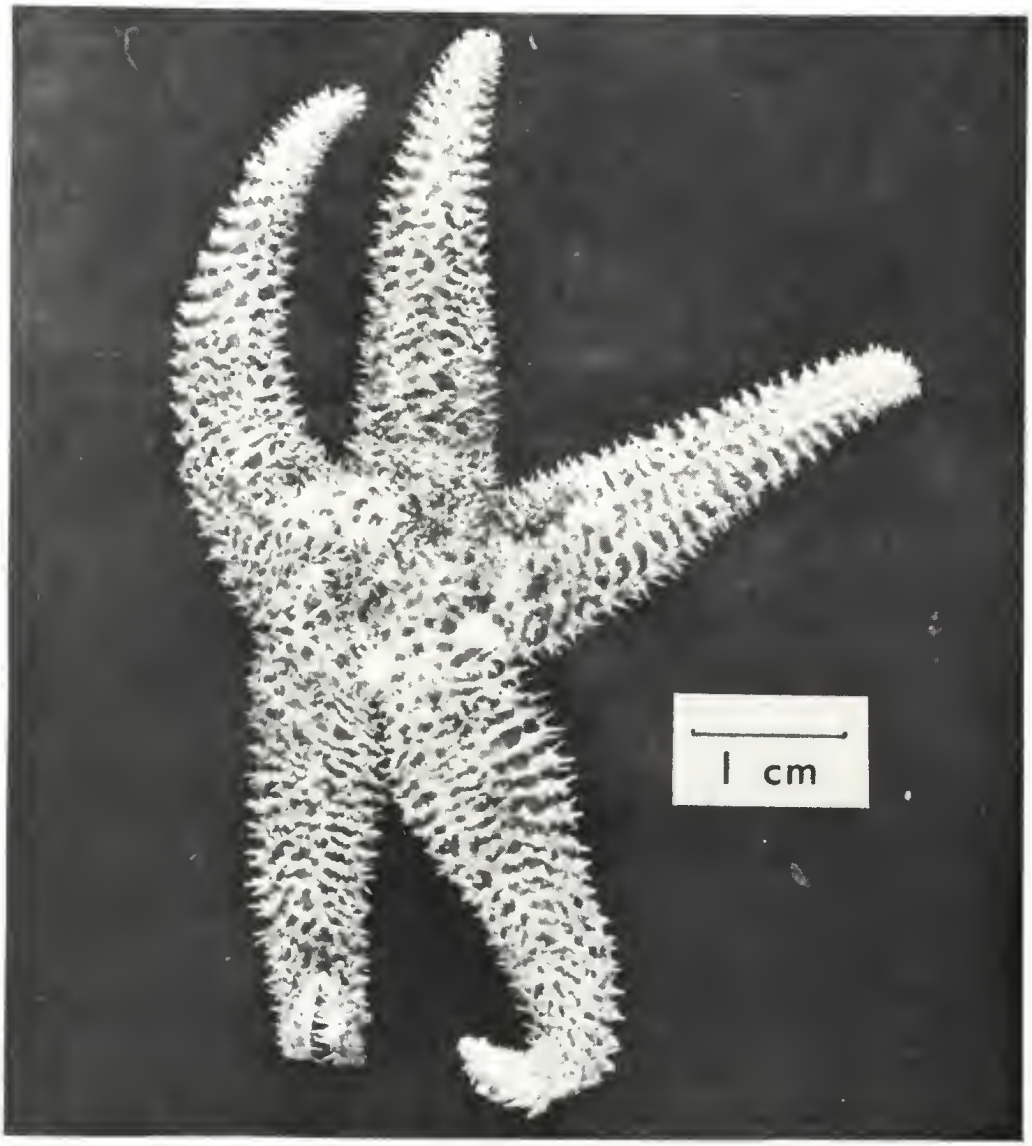

FIG. 45. *Leptasterias groenlandica*. Note the narrow, transversely elongate papular areas between the carinal and marginal plates of the rays.

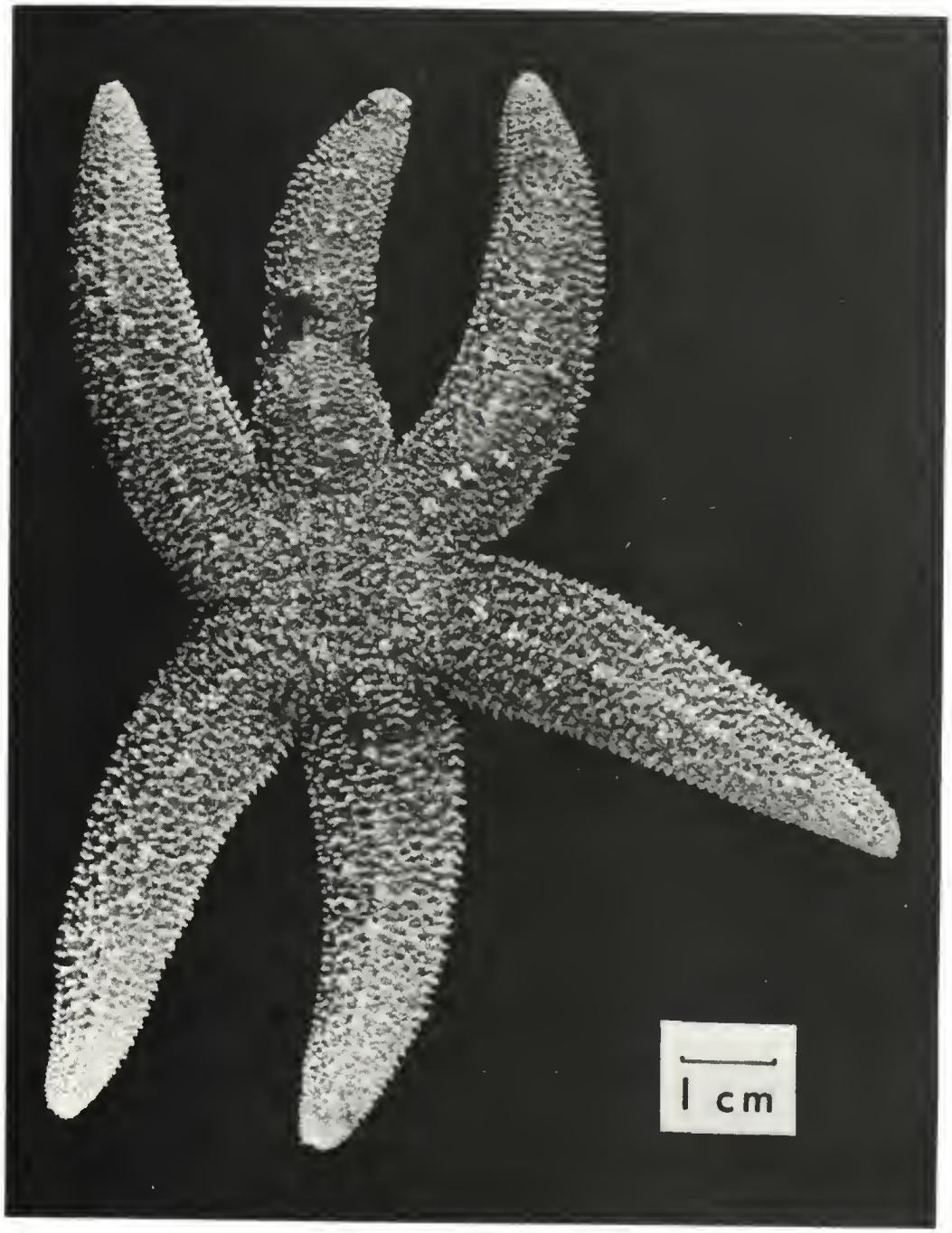

FIG. 46. *Leptasterias polaris*. Note the close mesh of the aboral surface of the disc and rays, the bulbous spines, and the scattered occurrence of spine groups consisting of a large central and smaller peripheral spines.

DESCRIPTIONS OF THE SPECIES

Descriptions of 29 species follow in this section. To date only 24 of these have been reported from waters covered by this report. Several others, however, have been recorded from waters adjacent to the present area and may reasonably be expected to occur in northern North American waters; five of these are described here. Under each species, collections are generally indicated by station numbers only. These numbers refer to Table II, which gives location, depth, and nature of bottom for each station where collections were made. Distribution of the 24 species within the area is shown below in a series of maps.

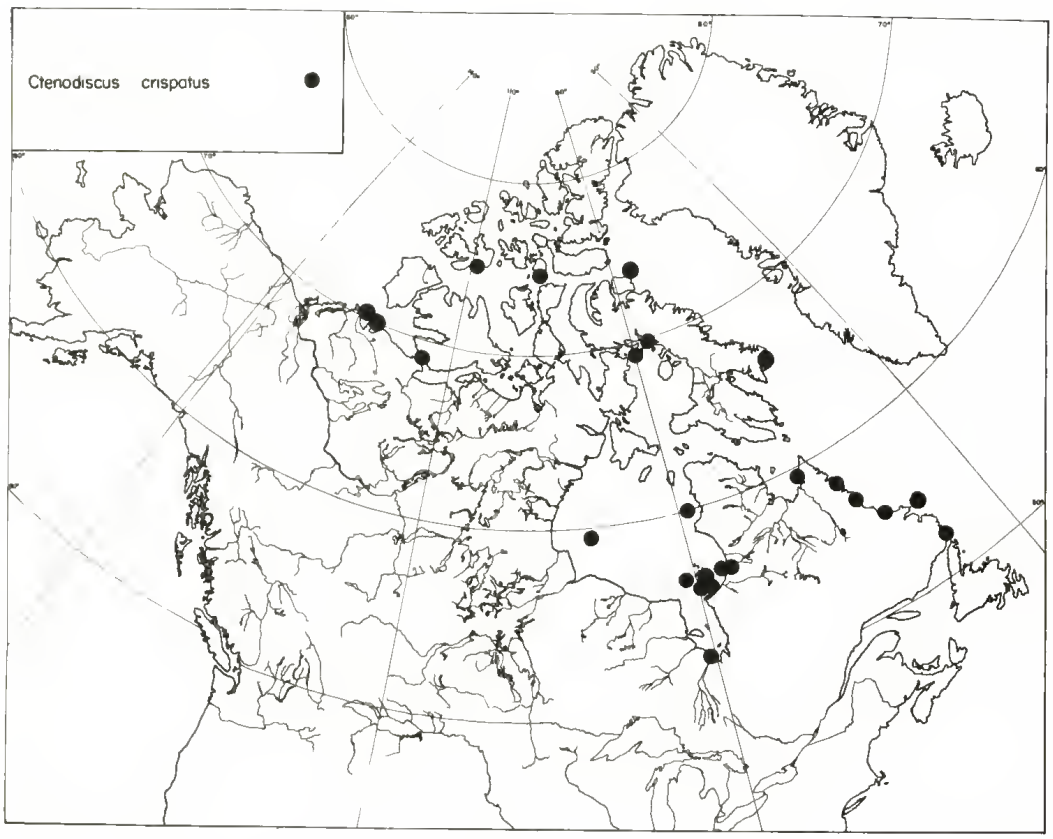

FIG. 47. Northern North American distribution of *Ctenodiscus crispatus*.

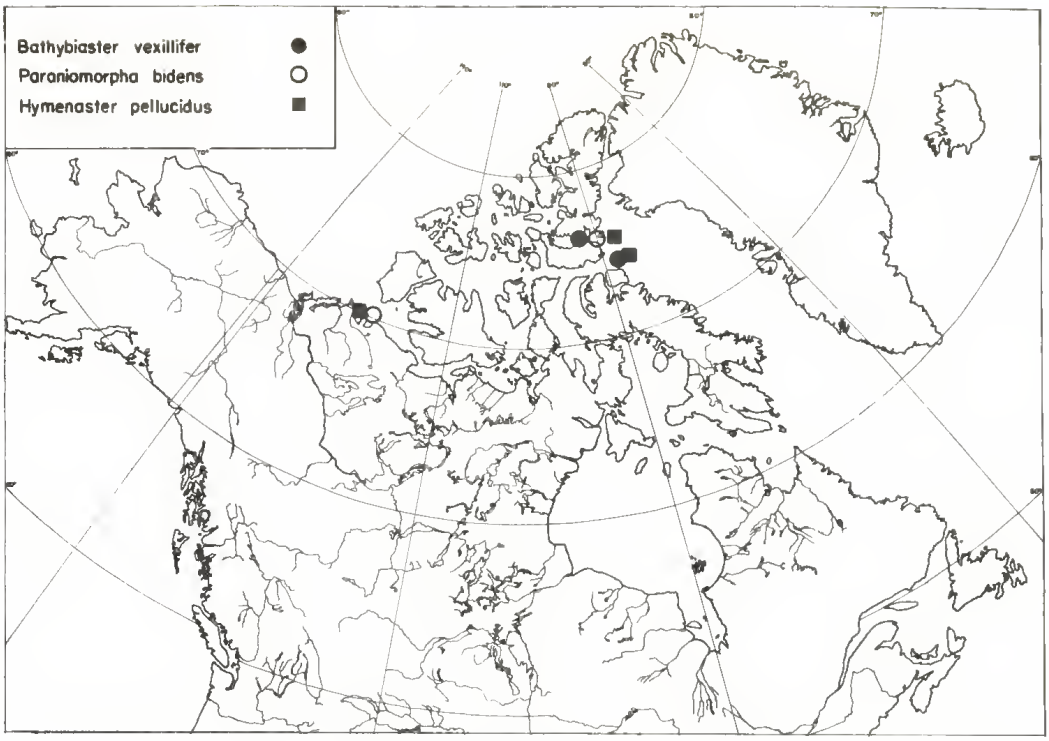

FIG. 48. Northern North American distribution of *Bathybiaster vexillifer*, *Poraniomorpha bidens*, and *Hymenaster pellucidus*.

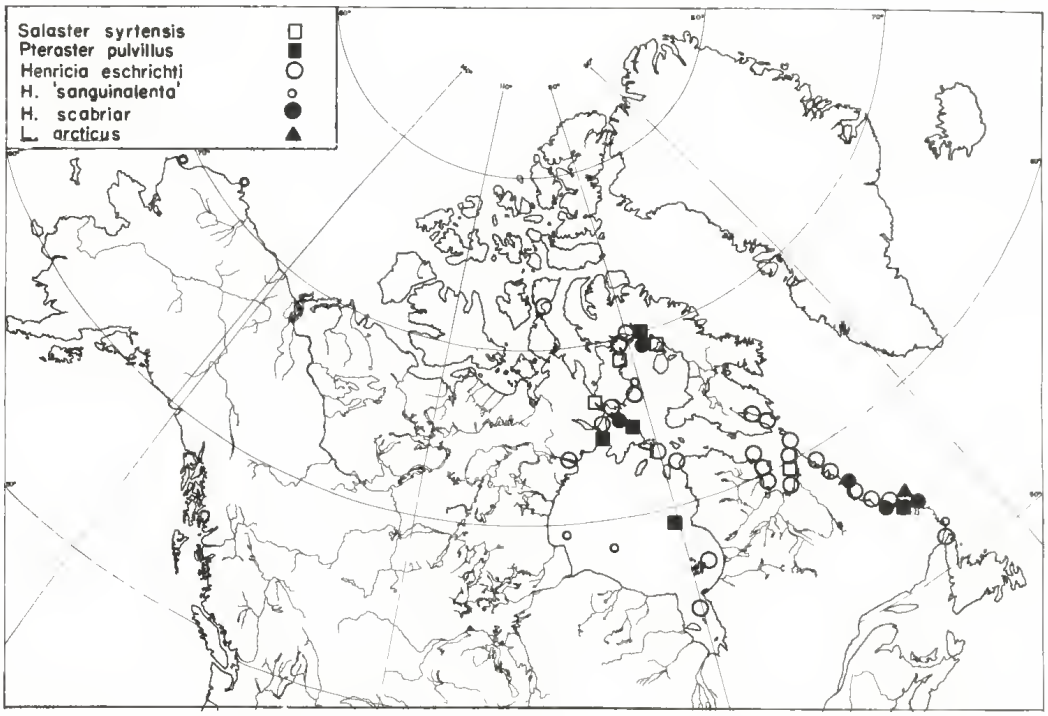

FIG. 49. Northern North American distribution of *Solaster syrtensis*, *Pteraster pulvillus*, *Henricia eschrichti*, *H.* "*sanguinolenta*," *H. scabrior*, and *Leptychaster arcticus*.

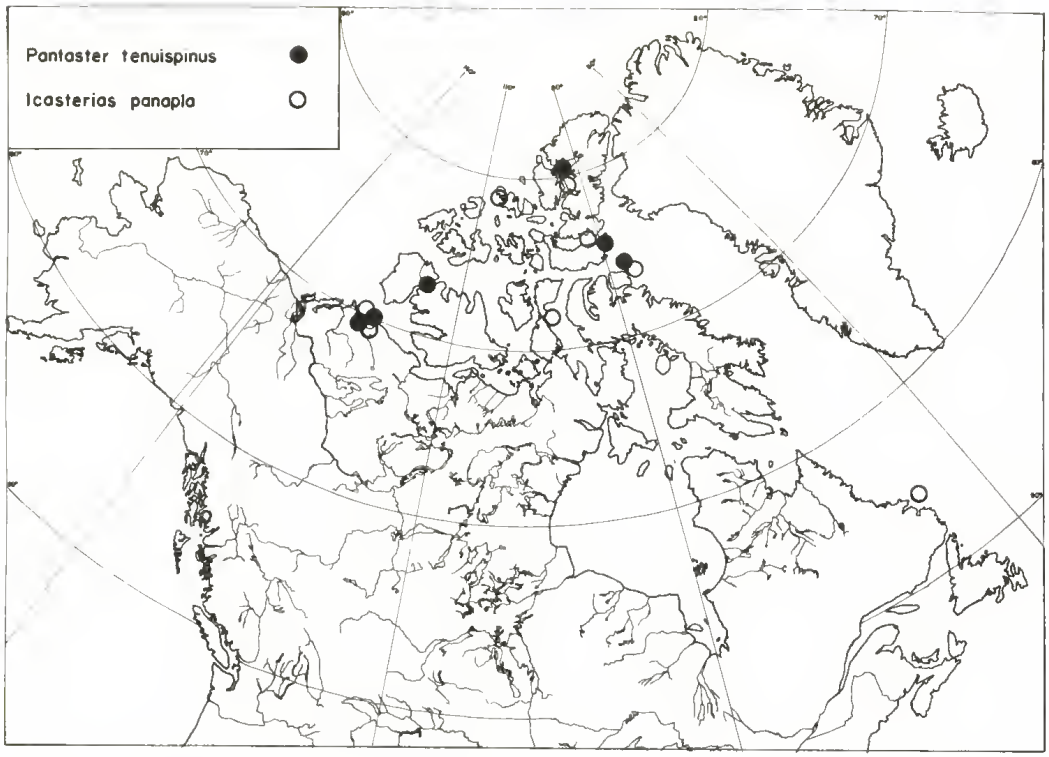

FIG. 50. Northern North American distribution of *Pontaster tenuispinus* and *Icasterias panopla*.

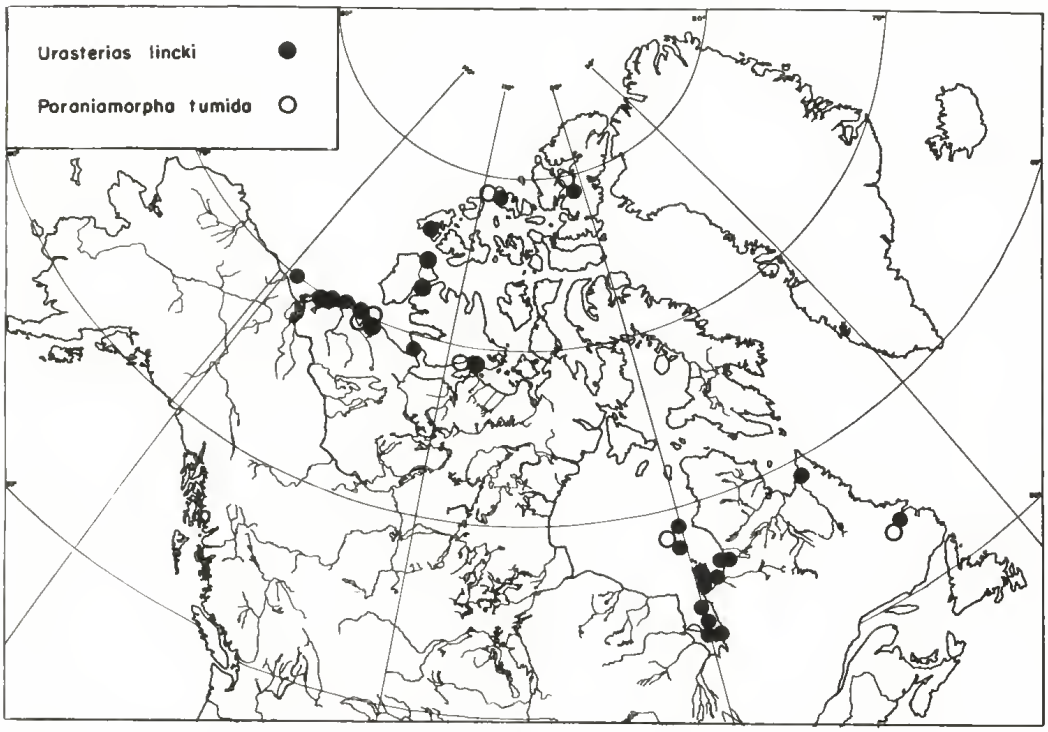

FIG. 51. Northern North American distribution of *Urasterias lincki* and *Poraniomorpha tumida*.

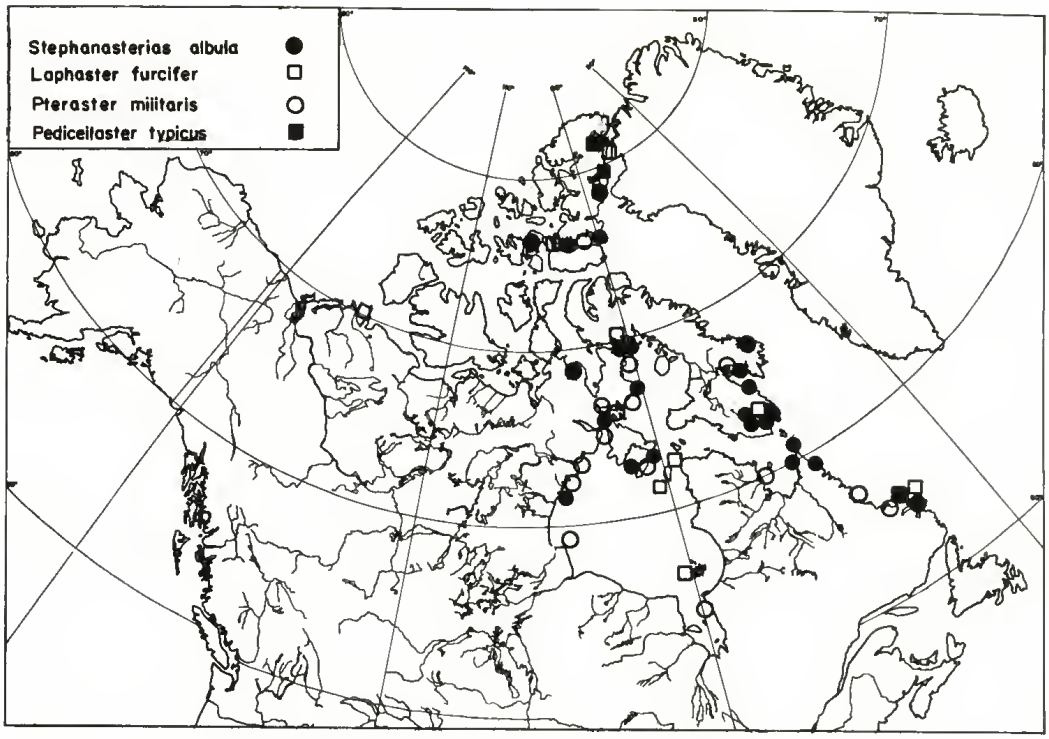

FIG. 52. Northern North American distribution of *Stephanasterias albula*, *Lophaster furcifer*, *Pteraster militaris*, and *Pedicellaster typicus*.

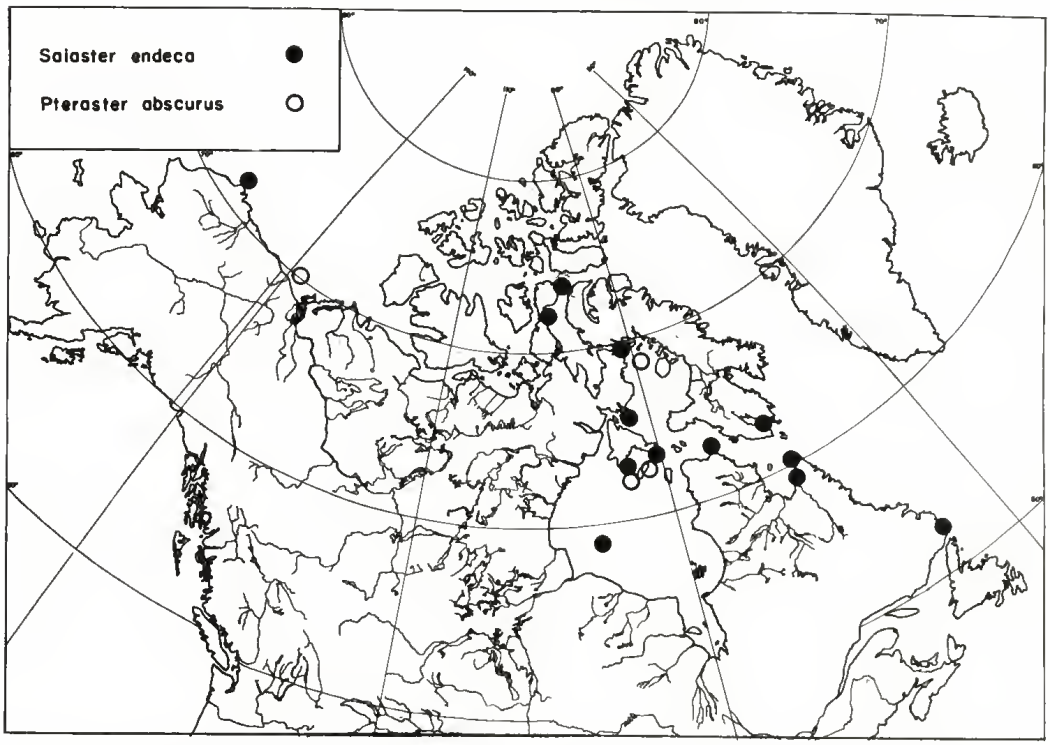

FIG. 53. Northern North American distribution of *Solaster endeca* and *Pteraster obscurus*.

Order PHANEROZONIA

Family PORCELLANASTERIDAE

Ctenodiscus crispatus (Retzius) (Fig. 2, 3, 4, 47)

Asterias crispata Retzius, 1805, p. 17
A. polaris Sabine, 1824, p. 223, pl. 1(1 2)
Ctenodiscus corniculatus Duncan and Sladen, 1881, p. 49, pl. 3(17–20)
C. crispatus Doderlein, 1900, p. 221, pl. 9(2, 3, 3a)
C. crispatus Fisher, 1911, p. 31, pl. 3(1–4), 4(1 6)
C. crispatus Mortensen, 1927, p. 53, fig. 30
C. crispatus Heding, 1935, p. 12, fig. 3

Usually 5 (rarely 4 or 6) rays. R:r about 1.6:1 to 3.0:1. Aboral skeleton of closely set paxilliform plates bearing clusters of usually 6–9 short spines. Frequently an elevated cone near the centre of the disc. Large supramarginal plates, larger than inframarginals, each with a long spine near the aboral margin, these spines forming a conspicuous "fence" between the lateral and aboral surfaces. Inframarginal plates each with a single spine. Adambulacral plates with an oblique row of about 3–5 spines. Tube-feet without flat sucking discs.

Specimens in the present collection, from 15 to 70 mm in diameter, show a fairly regular relative increase in ray length (R:r 1.6:1 to 2.1:1), ray width (6–22 mm at the base), maximum number of aboral spines per plate (6–19), and supramarginal plates per ray (7–16) with increase in diameter of the individuals. The maximum number of adambulacral spines per plate remains fairly constant at 3–5 throughout the size range. All but 3 have 5 rays; 3 abnormal specimens have only 4.

Collection: 271 specimens; 9–205 m; mud, mud-rock, mud-sand, rock-sand. Stations: 818, 832, 901b, 58-36, 58-37, 59-1, 59-35, 59-37, 59-38, 59-40, 59-43, 59-70, 59-72, 62-042, 62-043, 63-004, 63-005, 63-010, 63-012, 63-014, 63-018(b), 63-020, 63-031, 63-032, 63-034.

Figure 47 shows occurrence in northern Canada, where recorded depths are 2–680 m, bottoms nearly all of mud or mud and rock, rarely mud and sand or rock and sand, sand, or rock, bottom temperature from –1.7 to 3 C, and bottom salinity from 27 to 33‰. It is a circumpolar species distributed from the Arctic Ocean to the Faeroes and New England in the Atlantic and to Panama and Japan in the Pacific.

Family ASTROPECTINIDAE

Bathybiaster vexillifer (Wyville Thomson) (Fig. 5, 48)

Archaster vexillifer Wyville Thomson, 1873, pl. 150
Bathybiaster pallidus Danielssen and Koren, 1884, p. 89, pl. 14(1–15)
B. vexillifer Mortensen, 1910, p. 252, pl. 14(2, 5), 17(8, 14)
B. vexillifer Mortensen, 1927, p. 61, fig. 35

Five rays, tapering to fine points. R:r about 4:1 to 6:1. Aboral skeleton of closely set paxilliform plates, each with about 4–14 round grains. High and narrow supramarginal plates, not conspicuously different in size from the inframarginals, each with a single conspicuous but relatively small spine at the dorsal edge, inframarginals each often with 1–4 obvious spines one of

which is usually at the ventral margin, fewer near the tip than near the base of the ray. Adambulacral plates each with about 7 spines, the central one of each plate projecting far over the groove and forming, along with the 3 spines usually found on each side of it, a triangular arrangement with the apex pointing medially. Two rows of tube-feet, in wide ambulacral grooves, without flat sucking discs.

This species was not found in the present collections. Figure 48 shows occurrence in northern Canadian waters limited to Jones Sound (610 m, mud, –0.6 C) and off Lancaster Sound (680 m, mud, –0.4 C) (Mortensen, 1932). Distribution is from northeast Canada eastward to the Laptev Sea and as far south as south Davis Strait, Iceland, and northern Norway.

Leptychaster arcticus (M. Sars) (Fig. 49)

Astropecten arcticus M. Sars, 1851, p. 161
Leptychaster arcticus Fisher, 1911, p. 43, pl 8(1), 9(4)

Five blunt, tapering rays. R:r about 2:1 to 3.2:1. Aboral skeleton of closely set paxilliform plates bearing many very small spines. Supramarginal plates clearly smaller than the inframarginals. Supramarginals forming the margin of the aboral ray surface, inframarginals, not necessarily corresponding exactly to the supramarginals, obliquely aligned and forming the lateral ray surface. Both plate rows with numerous, small, undifferentiated spines. Adambulacral plates with usually 3 or 4 slender groove spines and usually 2 or 3 longitudinal rows of about 3–5 spines in each along the margin of the groove. Two rows of tube-feet, without flat sucking discs.

This species did not occur in the present collections. It was taken a few miles off the Labrador coast (Mortensen, 1932) from a rock bottom in 314 m at 2.8 C (Fig. 49). Its range is from West Greenland to Delaware Bay, south and west Iceland, and from the Barents Sea to the British Isles in the Atlantic sector, and from the Bering Sea to the Sea of Japan.

Family BENTHOPECTINIDAE

Pontaster tenuispinus (Düben and Koren) (Fig. 6, 50)

Astropecten tenuispinus Düben and Koren, 1846, p. 251, pl. 8(20–22)
Archaster tenuispinus Sars, 1861, p. 38, pl. 3(5–7)
Pontaster tenuispinus Bell, 1892, p. 430, pl. 26
P. tenuispinus Koehler, 1909, p. 10, pl. 10(1–4), 12(6)
P. tenuispinus Mortensen, 1927, p. 72, fig. 40

Five rays, tapering regularly, usually to a fine point. R:r about 3:1 to 7.4:1. Aboral skeleton of small, closely spaced paxilliform plates with about 3–30 (usually 8–20) short, blunt spines arranged circularly, often in 1 sometimes in 2 rows, and often encircling a relatively long, stout, pointed spine which rises from the centre of the plate to several times the height of the surrounding spines. Many plates, especially the smaller ones, lacking the large central spine which, being easily dislodged, may also be artificially absent from large areas of individuals or missing completely. Near the base of the ray supramarginal plates, usually conspicuous, each with a single long, thin spine near the centre, inframarginals, also usually conspicuous, with a single long spine near the aboral margin and several (often 2 or 3) shorter spines, diminishing in length towards the oral margin. Both plates also with a covering of fine spines. Towards the

extremities of the rays the arrangement of marginal plates and spines often variable. Adambulacral plate spines variable, often including about 6 in number along the margin of the groove and 1–3 larger ones placed more or less transversely along the oral surface. Tube-feet in 2 rows, with flat sucking discs.

Collection: 46 specimens; 50–200 m; mud, rarely sand. Stations: 62-043, 62-1108, 63-006, 63-011, 63-012, 63-014, 63-019, 63-020, 63-031, 63-032. In addition, 5 specimens were collected from soft mud bottoms between 20 and 81 m in Slidre Fjord, west Ellesmere Island, in August 1955 by S. D. MacDonald.

Northern Canadian occurrence is shown in Fig. 50. In this region recorded depths are from 20 to 680 m, bottoms are nearly all of mud only (two of sand), temperatures from −1.5 to 2.2 C, salinities from 32.5 to 34‰. The species is recorded from northwest Canada eastward to the East Siberian Sea, and southward in the Atlantic to New England and the Bay of Biscay.

Family Poraniidae

Poraniomorpha tumida (Stuxberg) (Fig. 7, 51)

Solaster tumidus Stuxberg, 1878, p.31
Asterina tumida Danielssen and Koren, 1881, p. 182, pl. 1, 2(6–10)
A. tumida Danielssen and Koren, 1884, p. 60, pl. 10(1–4), 11(7–8), 15(2)
A. tumida tuberculata Danielssen and Koren, 1884, p. 63, pl. 10(5–7), 15(3)
Rhegaster tumidus Döderlein, 1900, p. 219, pl. 9(1–1a)

Five rays. R:r about 1.6:1. Aboral surface strongly convex, with numerous closely spaced spines narrow at their base and expanded terminally as a cluster of minute points. Marginal plates almost concealed by a thick cover, the inframarginals with groups of longer and thicker spines than those found aborally, forming a sharp margin between the lateral and oral surfaces. Interradial surfaces often with a few scattered spines conspicuously longer than the majority of spines there which are much more scattered than dorsally. Adambulacral plates characteristically with 6 spines arranged in 2 transverse rows, or occasionally more than 6 spines in 2 or 3 rows, the spines nearest the groove the longest. Oral plates each with the spine closest to the mouth opening the longest, although not especially conspicuous, being similar in size and shape to the adambulacral spines, and projecting medially. Tube-feet in 2 rows, with flat sucking discs.

The form *tuberculata*, according to Danielssen and Koren, differs in having relatively longer rays (R:r to about 2.4:1), numerous solitary tubercles on the aboral surface of the disc and rays, and adambulacral plates with usually only 3–4 spines in a single transverse row. From northern Canadian specimens examined by the writer, it is suggested that form *tuberculata* may have yet longer rays (R:r to about 2.7:1), and a more variable adambulacral spine arrangement than shown by Danielssen and Koren. These spines appear in both single and double transverse rows in the former from 3 to 5 and most frequently from 4 to 5 per plate, in the latter usually as 8 per plate. Only a few specimens of form *tuberculata* have been described and little about variation within the form or of possible intermediates to *P. tumida* and form *tuberculata* is known. The possession of dorsal tubercles and of only a single row of spines on the majority of adambulacral plates is the criterion used to place the present specimens, at least tentatively, in the form *tuberculata*.

The largest of the specimens examined has a diameter of 65 mm, and the R:r value for all 8 specimens is 2.0:1 to 2.3:1. All show conspicuous dorsal tubercles, and the great majority of adambulacral plates bear single rows of 4 spines each. The 2 specimens from Slidre Fjord show puzzling differences. One (diameter 41 mm, R:r 2.2:1) fitted closely to Danielssen's and Koren's description. The other (diameter 40 mm, R:r 2.3:1) differed in its adambulacral spine arrangement, some being in single rows and some in double rows—the former being mostly distal to the centre of the rays, the latter for the most part in the proximal half of the rays. Similar but more extensive variation was noted in Labrador specimens of the form (Grainger, 1964).

Collection: 8 specimens; 2–200 m; mud, sand-mud. Stations: 62-3001, 62-7300, 63-006, 63-012, 63-031, 63-032. Five additional specimens were examined, collected by S. D. MacDonald in August 1955 from soft mud in about 20 m in Slidre Fjord, west Ellesmere Island, and in August 1954 from a mud bottom in 16 m near Isachsen, Ellef Ringnes Island.

Northern Canadian distribution is shown in Fig. 51. Depths are 2–200 m; bottoms, except for one of stones reported from Hudson Bay by Clark (1937), are mud, or rarely mud-sand or mud-rock; bottom temperatures are –0.9 to 2.0 C; salinities 25–34‰. *Poraniomorpha tumida* (including *P. tumida tuberculata*) is distributed from the Canadian arctic eastward to the East Siberian Sea, and southward in the Atlantic to Labrador and the north part of the British Isles.

Poraniomorpha bidens Mortensen (Fig. 48)

Poraniomorpha bidens Mortensen, 1932, p. 9, pl. 1(1–3)

Five rays. R:r about 2.0:1 to 2.5:1. Aboral surface slightly convex with many small closely spaced spines much like those of *P. tumida*. Marginal plates, barely visible through their thick spine cover, with spines similar to the dorsal ones but somewhat more closely spaced. Interradial surfaces with very close spines, longer than the dorsal and marginal ones, usually lying flat. Ambulacral groove conspicuously wider than in *P. tumida*, with irregularly placed spines, conspicuously long and forming transverse rows with a maximum of at least 15 spines per plate; those spines farthest from the groove the shortest, being little longer than the adjacent ventrolateral spines. Oral plates each with the spine closest to the mouth opening by far the longest, extremely conspicuous, considerably longer and thicker than any other ventral spines, and usually pointing away from the mouth. Tube-feet often, although not always, in a readily distinguishable 4-row pattern.

Only a single specimen occurred in the present collection, with a diameter of 108 mm, R:r 2.0:1. It shows excellent agreement with Mortensen's description.

Collection: 1 specimen; 170 m; mud. Station 63-014.

The northern Canadian distribution of the species is shown in Fig. 48, where the depths are 170 and 610 m, bottoms are of mud only, temperatures are –1.27 and –0.6 C, and the only salinity 33.3‰. Elsewhere it is distributed from Baffin Bay to the Kara Sea, nowhere south of 70°N lat.

Order SPINULOSA

Family PTERASTERIDAE

Diplopteraster multipes (M. Sars) (Fig. 12)

Pteraster multipes M. Sars, 1877, p. 65, pl. 8(1–17)
Diplopteraster multiples Fisher, 1911, p. 371, pl. 107(1–2)

Usually 5 rays, rarely 6. R:r about 1.3:1 to 1.5:1. Aboral and marginal plates covered by a rough bristling membrane. Paxillae with long pedicels, on top of which are a conspicuous central spine and about 7–9 shorter peripheral spines. Adambulacral plates with 2 kinds of webbed sets of spines, the more conspicuous combs with about 4–5 spines alternating with less conspicuous combs with about 3–4 spines. Oral plates with about 4–6 marginal spines, those of adjacent series united by a web. Tube-feet in 4 rows.

It was not found in the present collections, nor has it yet been found west of Greenland. Its range is from West Greenland east to the Barents Sea and south to Cape Hatteras and southernmost Norway, in the Atlantic, and from the Bering Sea south to California and the Sea of Japan, in the Pacific.

Pteraster militaris (O. F. Müller) (Fig. 9, 52)

Asterias militaris Müller, 1776, p. 234
Pteraster militaris M. Sars, 1861, p. 48, pl. 3(8–9), 4, 5, 6(1–13)
P. militaris Duncan and Sladen, 1881, p. 46, pl. 3(13–16)
P. militaris Danielssen and Koren, 1884, p. 70, pl. 13(18–19)
P. militaris Fisher, 1911, p. 346, pl. 98(1–2)
P. militaris Mortensen, 1927, p. 104, fig. 58, 60

Usually 5 rays. R:r about 1.9:1 to 2.5:1. Disc slightly convex, covered by a thick membrane with small calcareous deposits. Paxillae with low pedicels, only little higher than broad, each supporting terminally about 2–5 slender spines several times longer than the pedicel. Ventrolateral membrane, supported by the outermost spine of each row of adambulacrals, narrow with a free margin. Adambulacral plates with transverse rows of about 5–9 webbed spines, the outermost of each row the longest and supporting the ventrolateral membrane. Oral plates with about 6–8 webbed marginal and a single stout suboral spine. Spine sets of adjacent oral plates usually not joined by a web. Tube-feet in 2 rows.

Specimens in this collection vary from 30 to 71 mm in diameter and from 2.1:1 to 2.4:1 in R:r. All have 5 rays.

Collection: 13 specimens; 42–189 m; rock, rock-mud. Stations: 613, 711, 716, 818, 59-15, 61-5, 61-13, 61-26, 61-28, 61-32, 61-39.

Occurrence in northern Canada is shown in Fig. 52, where records of depths are from 6 to 610 m; bottoms are mostly of rock or of rock and mud (rarely mud); bottom temperatures are from −1.7 to 3.0 C; and bottom salinities are from 30 to 33‰. Known distribution is from eastern North America, east to the Chukchi Sea. In the Atlantic area it is recorded as far south as 40°N lat in the west and as far south as the British Isles in the east; in the Pacific area, south to the northwest US and to the Sea of Japan.

Pteraster pulvillus M. Sars (Fig. 10, 49)

Pteraster pulvillus M. Sars, 1861, p. 62, pl. 6(14–18), 7, 8
P. pulvillus Döderlein, 1900, p. 217, pl. 8(10, 10a)

Usually 5 rays. R:r about 1.3:1 to 1.9:1. Disc high, covered aborally by a membrane roughened by tips of paxillae spines. Paxillae with high pedicels, about 4 times as high as broad, each with about 6–15 slender diverging spines which are shorter than the pedicel. Ventrolateral membrane narrow, longest at about the fourth spine, narrowing towards the tip of the ray. Adambulacral plates at the base of the ray each with about 6 spines in transverse webbed rows, usually the innermost the shortest, the spine next to the outermost the longest. The number of these spines diminishes towards the tip of the ray. Oral plates each with about 6 or 7 webbed marginal spines and a single suboral spine a little longer than the inner (longest) marginal spine. Both series on adjacent oral plates joined by a web. Tube-feet in 2 rows.

Specimens studied range from 27 to 42 mm in diameter and from 1.6:1 to 1.9:1 in R:r. All have 5 rays.

Collection: 7 specimens; 42–145 m; rock, rock-sand, rock-mud. Stations: 832, 837, 58-28, 61-26, 61-32, 61-39.

The records from northern Canada are shown in Fig. 49. Bottom temperatures were −1.4 to 1.8 C, salinities 32.5–33.3‰, substrate mud-rock, rock-sand, and rock. Distribution is from Foxe Basin and Hudson Bay east to the Bering Sea, and southward in the Atlantic to Nova Scotia and southern Norway, in the Pacific to the Sea of Japan.

Pteraster obscurus (Perrier) (Fig. 11, 53, 54)

Hexaster obscurus Perrier, 1896, p. 41, pl. 3(1)
Pteraster obscurus Döderlein, 1900, p. 213, pl. 8(1–9)
P. obscurus Fisher, 1911, p. 363, pl. 105(1–4), 106(1–2)

Rays usually 6, as many as 9. R:r about 1.2:1 to 1.7:1. Aboral surface convex, covered by a tough, thick bristling membrane. Paxillae with short pedicels, about 2 or 3 times as high as broad, each with about 6–8 peripheral spines, one of which is often longer than the rest, and about 4–8 shorter, more slender central spines. Long spines a little longer than, short spines a little shorter than the pedicel. Ventrolateral membrane thick and wide. Adambulacral plates with transverse rows of about 4–7 webbed spines, the innermost the shortest. Oral plates with 5–6 webbed marginal spines, and a single suboral spine, shorter than the innermost marginal. Marginal spine series of adjacent oral plates connected by a web. Tube-feet in 2 rows.

Specimens of this collection have diameters from 17 to 54 mm, and R:r variation of 1.2:1 to 1.6:1. All have 6 rays.

Collection: 9 specimens; 89–137 m; rock, rock-mud, sand. Stations: 616, 716, 818, 60-1013.

Occurrence in northern Canada is shown in Fig. 53. The only former record from northern North America is from Hudson Bay (Clark, 1937) from 103 m on a stony bottom. Bottom temperatures at collection stations ranged from −1.4 to 0.2 C, while salinities were about 33‰. Distribution is from Foxe Basin and Hudson Bay east to the Kara Sea, and in the Atlantic region south to off Newfoundland,

FIG. 54. *Pteraster obscurus*. Note the ventrolateral membrane.

Iceland, and north Norway. It is found also in the Chukchi Sea and as far east as Herschel Island (Alaska–Yukon boundary), in the Bering Sea and the Sea of Okhotsk. It appears to be absent from most of northern Siberia and from the central portion of northern Canada.

Hymenaster pellucidus W. Thomson (Fig. 48)

Hymenaster pellucidus W. Thomson, 1873, p. 120, fig. 16
H. pellucidus Danielssen and Koren, 1884, p. 72, pl. 13(1–17), 15(7–8)
H. pellucidus Mortensen, 1927, p. 107, fig. 62–63

Five rays. R:r about 1.5:1 to 2.0:1. Aboral surface arched. Large nidamental cavity covered by a well-developed integument, pierced centrally by a conspicuous, funnel-shaped aperture. Around the opening, 5 large semicircular paxillae, each with 2 series of spines, with about 6–8 short spines in the outer row and 8–10 larger spines in the inner row. Five pairs of paxillae surrounding those above, and 4 rows of paxillae, often rather irregular, extending along each ray, each with about 4 long and 3 shorter spines in a roughly circular arrangement. Ventrolateral membrane conspicuously wide, supported by long slender spines, their maximum length approxi-

mately equal to the maximum width of the ray proper. Adambulacral plates usually with 3 additional spines, 2 pointing towards the groove, the third pointing laterally. This spine surrounded at its base by a calcareous network forming an irregularly 5-pointed collar, the whole surrounded by a membrane and forming a fleshy protuberance fitting neatly into semicircular spaces between adjacent spines of the ventrolateral membrane. Tube-feet in 2 rows.

Specimens in this collection have R of 34–39 mm, and R:r values of 1.5:1 to 1.9:1. All have 5 rays.

Collection: 13 specimens; 71–200 m; mud; temperatures –1.3 to –0.8 C; salinities 32–34‰. Stations: 63-006, 63-014, 63-031, 63-032, 63-034.

Occurrence in northern Canada is shown in Fig. 48. Only 2 records other than the ones above are reported, one from a mud bottom at 610 m in Jones Sound, the other from mud at 680 m off Lancaster Sound, at –0.6 and –0.4 C, respectively (Mortensen, 1932). The species, known formerly from Baffin Bay and adjacent waters east to the East Siberian Sea only, is shown here to reach the western Canadian arctic. Its southernmost limit appears to be north Iceland.

Family Solasteridae

Lophaster furcifer (Düben and Koren) (Fig. 13, 52)

Solaster furcifer Düben and Koren, 1846, p. 243, pl. 6(7–10)
Lophaster furcifer Duncan and Sladen, 1881, p. 43, pl. 3(9–12)
Solaster furcifer Greig, 1907, p. 8, pl. 1(2–5), 3(1)
Lophaster furcifer Grieg, 1921, p. 27
L. furcifer Mortensen, 1927, p. 116, fig. 69

Five rays. R:r 2.0:1 to 3.7:1. Aboral skeleton a fairly open network, of plates usually slightly overlapping and surrounding spaces nearly as large in area as the plates, occasionally of more widely separated plates not in contact with adjacent plates. Dorsal paxillae with stout pedicels, bearing as many as 30 long spines, each with from 2 to about 5 distal points. Marginal paxillae with up to 40 spines each, in 2 conspicuous and nearly equal rows. Adambulacral spines in 2 rows, the inner parallel to the groove, with about 3–5 spines, the outer at right angles to the groove, with about 3–6 spines, the latter webbed. Tube-feet in 2 rows.

The seven specimens in this collection have diameters from 62 to 140 mm. R:r values from 2.7:1 to 3.0:1. All have 5 rays. There are no readily distinguishable differences between specimens from the eastern and western parts of the present region. All appear to belong to the typical arctic or cold-water group of Grieg (1906, 1921) as reported from north of the Atlantic. It is perhaps significant that the western specimens show no closer agreement than do the eastern with *L. furcilliger* Fisher or *L. furcilliger vexator* Fisher. These forms, reported from the North Pacific by Fisher (1911) and later from the Sea of Okhotsk and the Sea of Japan by Diakonov (1950), have been referred to *L. furcifer* by Mortensen (1913, 1932) and Grieg (1921). The present western arctic material, originating from waters intermediate to *L. furcifer* and *L. furcilliger*, indicates that *L. furcifer*, as such, reaches to northwest Canada. If transitional forms between this and *L. furcilliger vexator* exist, they must be looked for between the western Canadian arctic and the Bering Sea.

Collection: 7 specimens; 70–200 m; rock, mud. Stations: 811, 815, 63-006, 63-031.

North Canadian occurrence is shown in Fig. 52. Known depth range in this region is 6–314 m; all bottoms are rock, rock-mud, rock-sand, or mud; temperatures are from –0.8 to 2.8 C; salinities from 32.6 to 34.0‰. The species, as *L. furcifer*, is distributed from eastern North America eastward to the Laptev Sea and in western Canadian arctic waters, and as far south in the Atlantic as New York and the British Isles. *L. furcilliger* and *L. furcilliger vexator*, both possibly varieties of *L. furcifer*, are reported, respectively, from Alaska to California (351–2012 m) and the Sea of Okhotsk, and from the Bering Sea to California (137–640 m) and the Seas of Okhotsk and Japan.

Solaster papposus (L.) (Fig. 14, 15, 16, 55, 56)

Crossaster papposus Duncan and Sladen, 1881, p. 36, pl. 3(1–4)
Solaster papposus Döderlein, 1900, p. 205, pl. 6(1–5)
S. papposus Grieg, 1907, p. 6, pl. 1(1–2), 2
S. papposus Fisher, 1911, p. 325, pl. 94(1–6)
S. papposus Mortensen, 1927, p. 112, fig. 66–67
S. papposus Heding, 1935, p. 34, fig. 14

Eight to 16 rays, most frequently 10–12. R:r about 1.7:1 to 2.7:1. Aboral skeleton an open reticulated network, with up to 50 spines per paxilla. Inframarginal plates with a single conspicuous row of paxillae; supramarginals almost indistinguishable from aboral paxillae. Inner adambulacral spines arranged parallel to the groove, numbering usually 3–4, occasionally 2 to at least 7; outer adambulacral spines in rows at right angles to the groove numbering usually about 5–7, rarely 3–9. Oral plates with 6–11 marginal spines. Tube-feet in 2 rows.

Among specimens in the collection there is considerable variation in the length of the aboral spines. For the most part, smaller individuals show long spines of the type illustrated by Heding (1935, fig. 14(1)) as the typical "arctic" form. Larger specimens, however, often show much shorter spines, resembling those of Döderlein's (1900) form *anglica*. In this collection, diameters range from 14 to 132 mm, R:r from 1.9:1 to 2.7:1, number of rays from 8 to 12 and number of marginal oral spines from 6 to 11. The maximum number of both inner and outer adambulacral spines is between 3 and 7 per plate. There is apparently a general relative increase in ray length with growth of the disc.

Collection: 60 specimens; 14–137 m; rock, rock-sand, rock-mud, mud, mud-sand, sand. Stations: 547, 715, 723, 811, 821, 828, 832, 837, 58-36, 59-29. 59-43, 59-69, 59-71, 60-1013, 61-1, 61-2, 61-10, 61-12, 61-13, 61-26, 61-39, 61-1082, 62-2008, 62-2030, 62-2031, 62-4001, 62-4003, 62-4011, 62-7300, 63-018(a), 63-032.

Occurrence in northern Canada is shown in Fig. 56, at which stations bottom temperatures have been recorded between –1.7 and 4 C, salinities between 25 and 33‰. Overall depth range is 4–225 m.

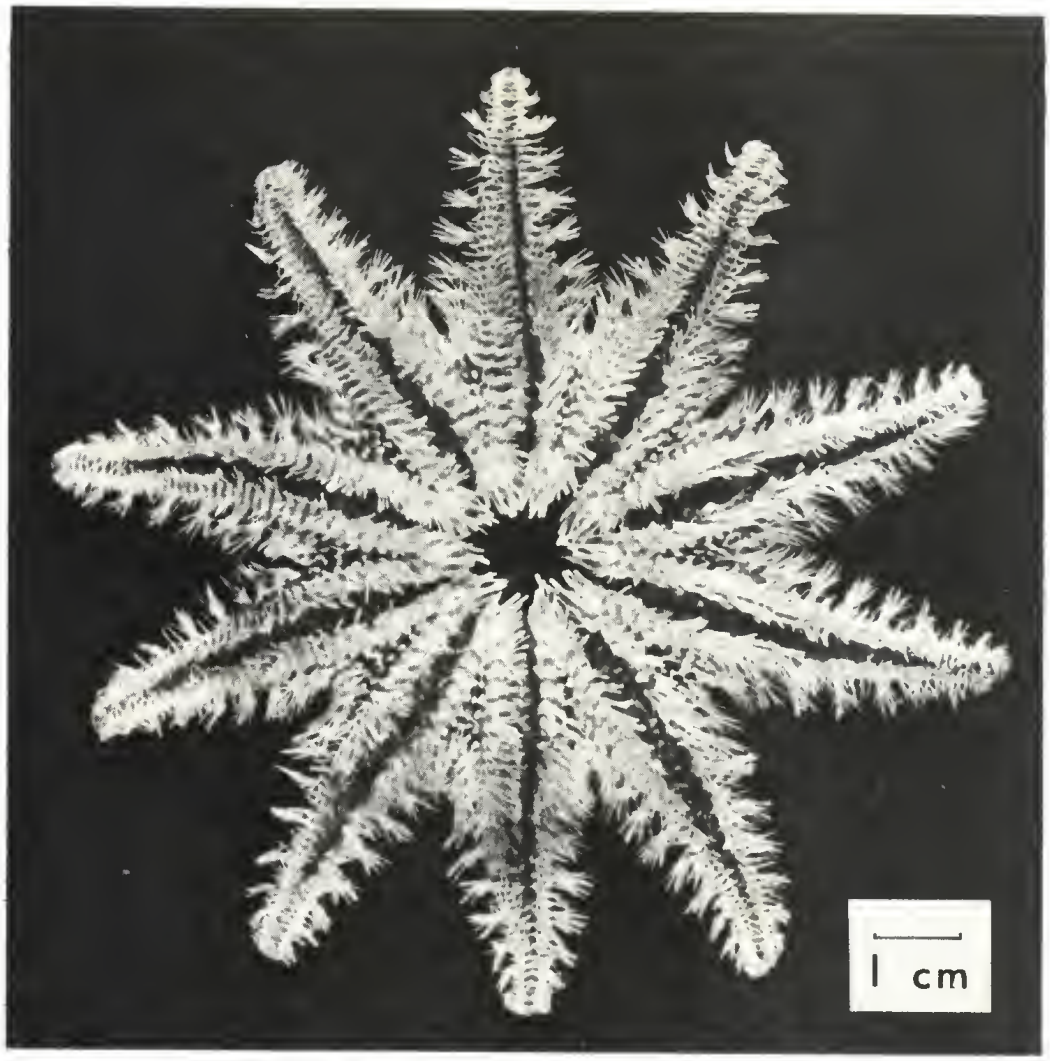

FIG. 55. *Solaster papposus*. Note the inframarginal spines bordering the rays, the oral plates separating adjacent ambulacral grooves where they join the mouth opening, the oral spines on the oral plates, and the triangular interradial areas between the adambulacral plates of adjacent rows.

Solaster squamatus Döderlein

Solaster papposus squamata Döderlein, 1900, p. 208, pl. 6(5)
S. squamatus Grieg, 1906, p. 46, pl. 1(4–5)
S. squamatus Mortensen, 1927, p. 114, fig. 66

Rays usually 9–11. R:r about 2:1 to 2.5:1. Resembling closely *S. papposus*, this species is distinguished by having the aboral skeleton of imbricated plates forming a closely meshed surface with very small open spaces containing single papulae.

The species was not found in the present collections. It has not yet been recorded from west of Baffin Bay and Smith Sound, although its occurrence in the Canadian arctic may be expected. It is know from Smith Sound, Baffin Bay, East Greenland, north and east Iceland, Spitzbergen, and the Barents Sea.

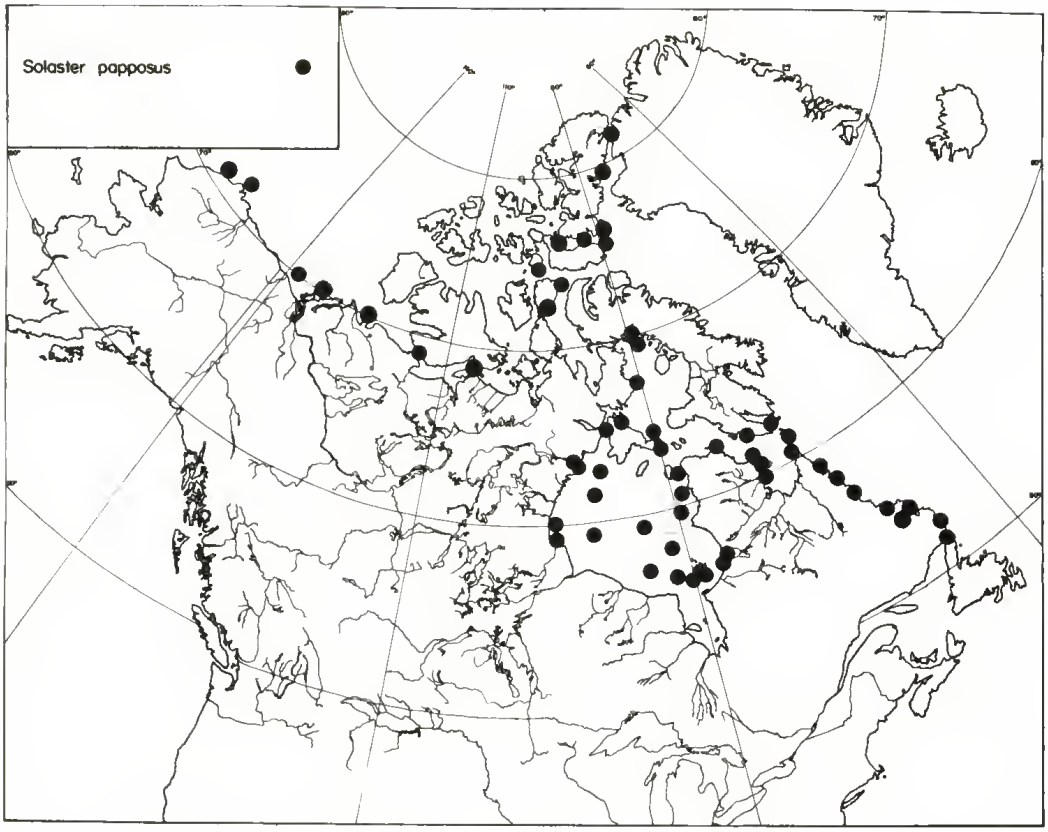

FIG. 56. Northern North American distribution of *Solaster papposus*.

Solaster glacialis Danielssen and Koren (Fig. 18)

Solaster glacialis Danielssen and Koren, 1884, p. 42, pl. 8(9–10), 9(1–6), 15(1)

Rays usually 7–10. R:r about 2.5:1 to 3.1:1. Aboral skeleton of usually 4-lobed plates forming a fairly open reticulated surface, the disc paxillae, spaced at about 1-mm intervals and in longitudinal rows on the rays, with about 3–12 spines. Both inframarginal and supramarginal paxillae readily distinguishable from adjacent paxillae, the inframarginals being the larger and forming a prominent border along the margin of the ray. Adambulacral plates with usually 3–4 small inner spines in rows parallel to the groove, and 4–5 much larger and more conspicuous outer spines, in rows at right angles to the groove. Oral interradial spaces with no paxillae and only rarely single spines. Tube-feet in 2 rows.

This species was not present in the collections. It has not been recorded from North America. Mortensen (1932) reported it from West Greenland, but Heding (1935) differed from Mortensen's identification of the specimens and referred them instead to *S. syrtensis* Verrill.

Solaster syrtensis Verrill (Fig. 17, 19, 49)

Solaster syrtensis Verrill, 1894, p. 271
S. syrtensis Döderlein, 1900, p. 120, pl. 7(2–3)
S. syrtensis Heding, 1935, p. 36, fig. 15–16
S. syrtensis Heding, 1936, p. 9

Rays 7–10, most frequently 9. R:r about 2.1:1 to 3.1:1. Aboral disc skeleton of more or less rounded, elongate or slightly lobed plates, varying in density from closely imbricated, leaving only few and small papular areas in small individuals, to a much looser reticulation with papular

areas almost equal in area to plates in larger specimens. Usually not more than a single papula in each open space. Aboral ray plates more densely placed than on the disc. Aboral surface paxillae closely placed, often in contact with one another, showing little regularity of arrangement except on the aboral interradial areas and on the dorsolateral surface of the ray bases, where more or less oblique rows may occur. Paxillae with low pedicels, and spines, numbering about 7–20, of about the same height, broad and depressed with flattened to concave tops. Inframarginal plates considerably larger than supramarginals, transversely elongate. Supramarginal paxillae much larger than adjacent dorsolateral paxillae. Inner adambulacral spines numbering 3–4, transversely placed rows of adambulacrals numbering about 4–7. Oral interradial spaces with well-developed paxillae with spines longer than those on the aboral paxillae.

Specimens in this collection range from 36 to 210 mm in diameter, with R:r values from 2.4:1 to 3.0:1, and number of rays 9. Inner adambulacral spines reach a maximum of 4, outer adambulacrals 4–7, and aboral paxilla spines about 20–25. This species appears to be a very variable one, especially in comparing small and large individuals. Heding's (1935) description of the aboral disc skeleton and the dorsolateral ray skeleton showed closely imbricated plates with only a few papular areas in a small specimen (R = 17 mm). Heding (1936), in specimens of R = 37 and 58 mm, found plates not nearly as closely imbricated as in the smaller individuals, and (p. 10) "nearly as many papulae as . . . plates." Some of the specimens in the present collection are larger than Heding's largest forms, and they show a progressive opening of the papular areas. Plates show a slightly lobed formation on the disc and towards the base of the rays; at the tips of the rays they are more rounded and much more closely placed.

Collection: 4 specimens; 55–110 m; mostly rock, rock-sand. Stations: 711, 718, 811, 837. An additional specimen, recorded as *S. endeca* (Grainger, 1955) from station 103 (rock, 145 m), northeast Ungava Bay, has since been found to belong to this species.

Northern Canadian occurrence is shown in Fig. 49. No previous North American records exist from north of Nova Scotia. In this collection bottom temperatures range from –0.6 to 0.0 C, salinities from 31.6 to 32.6‰. The species is known from eastern North America (Foxe Basin, Ungava Bay, Nova Scotia, and New England) east to the Laptev Sea and south in the east Atlantic to central Norway

Solaster endeca (L.) (Fig. 20, 53)

Solaster endeca Duncan and Sladen, 1881, p. 40, pl. 3(5–8)
S. endeca Danielssen and Koren, 1884, p. 50, pl. 9(13)
S. endeca Döderlein, 1900, p. 209, pl. 7(1, 1a, 1b, 4)
S. endeca Fisher, 1911, p. 307, pl. 81, 82(1, 2, 4)
S. endeca Mortensen, 1927, p. 115, fig. 68

Rays 7–13, most frequently 9 or 10. R:r about 2.3:1 to 3.3:1. Aboral paxillae small, higher than broad, more or less scattered, with from at least 4 to about 15 spines. Inframarginal plates larger than supramarginals, transversely elongate. Supramarginal paxillae only a little larger than adjacent dorsolateral paxillae, but clearly distinguishable from them. Inner adambulacral spines, set in the groove, from 1 or 2 to 4 in number, much shorter and less conspicuous

than the larger outer adambulacral spines. These, in transversely placed rows, vary from about 3 to 7 or 8 in number, the innermost spines the longest and stoutest, the outermost the smallest. Tube-feet in 2 rows. Oral interradial spaces with paxillae.

Specimens in this collection range from 144 to 210 mm in diameter, with R:r values from 2.3:1 to 2.6:1. There are from 8 to 10 rays. The maximum number of inner adambulacral spines per plate is from 2 to 3, of outer adambulacral spines from 6 to 7. The majority of adambulacral plates carry only a single spine in the groove.

Collection: 6 specimens; 36–110 m; rock and rock-mud. Stations: 547, 615, 811, 61-39, 61-43.

Occurrence in northern Canada is shown in Fig. 53, in which area the depth range is 18–118 m, bottoms are mostly rock, with two of rock-mud, and reported temperatures are 0–0.6 C, salinities 32.5–32.6‰. A previous record (Grainger, 1955) of a 150-mm specimen from *Calanus* station 103 (northeast Ungava Bay) has been shown to refer instead to the closely related *S. syrtensis* (above). *Solaster endeca* is recorded from the eastern Canadian arctic eastward to the Kara Sea and south to New England and the British Isles in the Atlantic, and from Point Barrow, Alaska, the Bering Sea and south to Vancouver Island in the Pacific.

Family Echinasteridae

Members of the genus *Henricia*, of this family, appear to be chronic sources of trouble to students of the group in northern waters. Verrill's (1914), Fisher's (1911, 1930), Heding's (1935) and Diakonov's (1950) reports on the *Henricia* species of the North Pacific, the North Atlantic, and the northern seas of the USSR include a host of allegedly different species and subspecies and many unnamed varieties. Only a few of these, however, are reported from waters adjacent to the region considered here.

Verrill reported *H. sanguinolenta* from Point Barrow, *H. sanguinolenta rudis* from Point Franklin, and *H. arctica* from Cape Lisburne (all north Alaska). Fisher (1911) referred to *H. sanguinolenta* and *H. sanguinolenta eschrichtii*, later (1930) as *H. sanguinolenta rudis* and *H. sanguinolenta tumida* (the latter including Verrill's *H. arctica*) from the same region. Diakonov again separated *H. tumida* and *H. arctica*, and added the new species *H. derjugini* from the Chukchi Sea. Heding listed *H. eschrichtii eschrichtii*, *H. eschrichtii laevior*, and *H. scabrior* from the northwest Atlantic, and Diakonov the same species from the northeast Atlantic.

Neither Heding nor Diakonov agreed with Fisher's designation of *H. sanguinolenta*, which they limited geographically to the region extending from Iceland and the Faeroes to the Kara Sea. Also neither evidently agreed with Fisher's identification of *H. sanguinolenta eschrichtii*, the geographical distribution of which (as *H. eschrichtii*) they described as the region extending from West Greenland and the Faeroes to the Barents Sea. *Henricia scabrior*, recognized by both authors, was shown to occur from west of Greenland to the East Siberian Sea.

Even the relatively few most northerly forms have been confused, and of these the most difficult name to categorize at present seems to be *H. sanguinolenta* (O. F. Müller). Müller's (1776) original description was unfortunately brief and vague, and it is probable that many workers since have used the name for specimens not in fact identical with Müller's. The majority of authors have used the name, or others considered by them to be synonymous with it, to refer to all members of the genus from northeastern North America and Greenland. Heding's (1935) work pointed out that none of the Greenland forms was what he considered to be *H. sanguinolenta.* The dominant southwest Greenland one he called *H. eschrichtii eschrichtii* and a more northern form of that he referred to as *H. eschrichtii laevior.* He limited *H. sanguinolenta* to the western Atlantic, and thus showed not only morphological but wide distributional differences between *H. sanguinolenta* and the others. Diakonov (1950) followed in almost complete agreement. Grainger (1955) applied Heding's and Diakonov's conclusions to *Henricia* from the eastern Canadian arctic and found exclusive occurrence of what was called *Henricia eschrichti eschrichti* in the waters adjacent to southeast Baffin Island. Farther south, along the Labrador coast (Grainger, 1964), *H. eschrichti* was again reported, along with *H. scabrior* (Mikh.).

For the present work *Henricia* specimens from the entire Canadian arctic area were examined, along with some from southeast Canada and the northeast US. Several apparently different forms have come to light, nearly all of them in the southern area. While both *H. eschrichti* and *H. scabrior,* in the sense used here, appear to extend well to the south of the area treated in this paper, at least two other apparently consistent forms exist in the same southern waters. Because of the confusion in naming, originating largely from the difficulty in defining the true *H. sanguinolenta* in the European waters where it was originally described, none of the other names of probably closely related species can be made firm at the present time. It is quite apparent now, however, that more than one species of *Henricia* exists in northeast North American waters, thus that even if the true *H. sanguinolenta* is found to occur there, it is only one of possibly as many as four species. Certainly at the present time it is clear that at least two distinct species of *Henricia* occur in waters covered by this report (north of southern Labrador). While either of them may ultimately be shown to be the true *H. sanguinolenta,* the best evidence available to date is that neither will fall into that species. For the present then the two species treated here are called *H. eschrichti* (Müller and Troschel) and *H. scabrior* (Mikh.) with awareness that name changes in either or in both may follow additional work on the genus elsewhere.*

**Footnote added in proof.* Rasmussen (1965) has recently distinguished three species of *Henricia* from the North Atlantic, two of them occurring in waters covered by the present report. The names *H. perforata* O. F. Müller and *H. sanguinolenta* O. F. Müller are suggested by Rasmussen, respectively, for *H. eschrichti* and *H. eschrichti lævior* combined and for *H. scabrior.*

Henricia eschrichti (Müller and Troschel) (Fig. 8, 21–25, 49)

Echinaster eschrichtii Müller and Troschel, 1842, p. 25
Cribrella oculata Duncan and Sladen, 1881, p. 32, pl. 2(18–21)
Henricia eschrichtii eschrichtii Heding, 1935, p. 26, fig. 8, 12(2), 13(7–8, 12–14)
Henricia eschrichti eschrichti Grainger, 1955, p. 902, fig. 1–3

Five rays. R:r about 3:1 to 4:1. Aboral skeleton irregularly and closely reticulated, dorsolateral, marginal and oral surface skeleton fairly regularly imbricated, with papular areas much narrower than plates. Carinal plates not readily distinguishable. Aboral paxillae with about 4–40 fairly small spines with usually 3 or 4 lateral ridges extending beyond the tip as a crown of 3 or 4 diverging points. Marginal plates large, conspicuous, in even imbricated rows and in close contact with adjacent rows. Adambulacral plates with usually 2 (sometimes 3) transverse rows of about 8–18 spines, the largest near the groove. Tube-feet in 2 rows.

Collection: 61 specimens; 14–148 m; mostly rock, rock-mud, rock-sand, occasionally mud. Stations: 547, 713, 715, 716, 722, 723, 811, 817, 818, 820, 837, 901d, 901e, 58-21, 59-15, 59-20, 61-10, 61-24, 61-26, 61-32, 61-39, 62-2012.

Figure 49 shows occurrence in northern North America (along with that of specimens referred to as *H. sanguinolenta*). Recorded depths are 14–148 m and bottoms are mostly of rock and mud-rock, with mud, mud-sand, and rock-sand. Temperatures vary from –1.8 to 4 C, salinities from 25 to 33‰. It is a species apparently characteristic of the Atlantic area, limited (from collections made to date, at least) to eastern North America, and extending eastward to the Barents Sea.

Henricia eschrichti laevior (Mikhaĭlovskiĭ) (Fig. 26–28)

Cribrella sanguinolenta laevior Mikhaĭlovskiĭ, 1903, p. 478
Cribrella sanguinolenta laevior Mortensen, 1910, p. 259
Henricia eschrichtii laevior Heding, 1935, p. 23, fig. 6, 7(a), 12(1), 13(15–17)

Five rays. R:r about 3:1 to 4:1. Aboral skeleton closely imbricated, with very few and exceedingly small open spaces. Aboral spines similar to form *eschrichti*. Marginal plates in even imbricated rows. Adambulacral plates with about 25–30 spines of similar length, placed irregularly.

This form did not occur in the present collection and is known from west of Baffin Bay and the coast of West Greenland. It is known from there eastward to Spitzbergen and the Kara Sea.

Henricia scabrior (Mikhaĭlovskiĭ) (Fig. 29–32, 49)

Cribrella sanguinolenta scabrior Mikhaĭlovskiĭ, 1903, p. 478
Henricia sanguinolenta scabrior Mortensen, 1910, p. 259; 1932, p. 15
H. scabrior Heding, 1935, p. 31, fig. 11, 12(5–6), 13(9–11)
H. scabrior Diakonov, 1950, p. 92, pl. 44–45

Five rays. R:r about 4:1 to 6:1. Aboral skeleton usually fairly delicate, of narrow plates forming a wide, irregular network, papular areas much wider than plates. Aborally, spines nearly always single, although often placed closely in rows. Spines, relatively long and enveloped in a soft membranous cover, without a terminal crown of projections but with short blunt irregular terminal extensions and narrow notched lateral ridges. No clearly defined marginals, but occasionally and very variably short and fairly regular rows of lateral plates. Within the skeletal

meshes frequently small isolated plates bearing single spines. Adambulacral spines in single transverse rows of about 4–7 spines each, sometimes those away from the groove showing a slight "zig-zag" arrangement. The largest spines adjacent to the groove, often conspicuously long and blunt, the rest gradually shorter away from the groove. A single groove spine on each plate often quite conspicuous.

Collection: 13 specimens; 42–145 m; rock-sand, rock-mud. Stations: 837, 61-32, 61-39.

Occurrence in northern Canada is shown in Fig. 49. Temperature range is –1.8 to 1 C, salinity 32–33‰. It appears to be a species of the Atlantic area, recorded from eastern Canada eastward to the New Siberian Islands.

Henricia sp. (Fig. 57–59)

Three specimens were found which could not be given specific names. One, from station 61-39, is about 65 mm in diameter, with R:r of 5:1. Its skeleton, both aborally and laterally, is much like that of *H. scabrior* (Fig. 57), but aboral spines are usually grouped, as 4 or 5 per plate, only occasionally single, and lateral spines are in slightly larger groups, numbering up to 7 or 8 per plate. Adambulacral spines are irregular, usually 2 or 3 in a single row near the groove, then 4–7 smaller ones, rather more irregularly placed, away from the groove (Fig. 58).

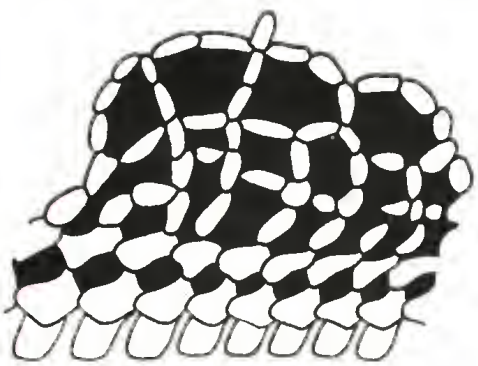

FIG. 57. *Henricia* sp., lateral ray plates.

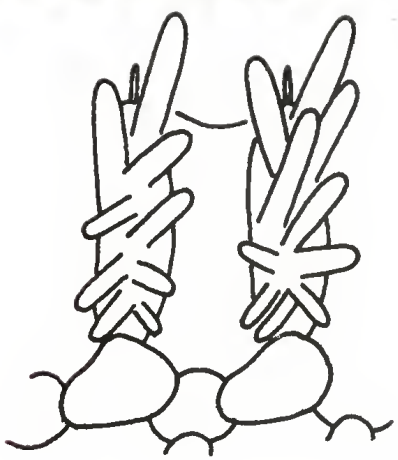

FIG. 58. *Henricia* sp., adambulacral spines.

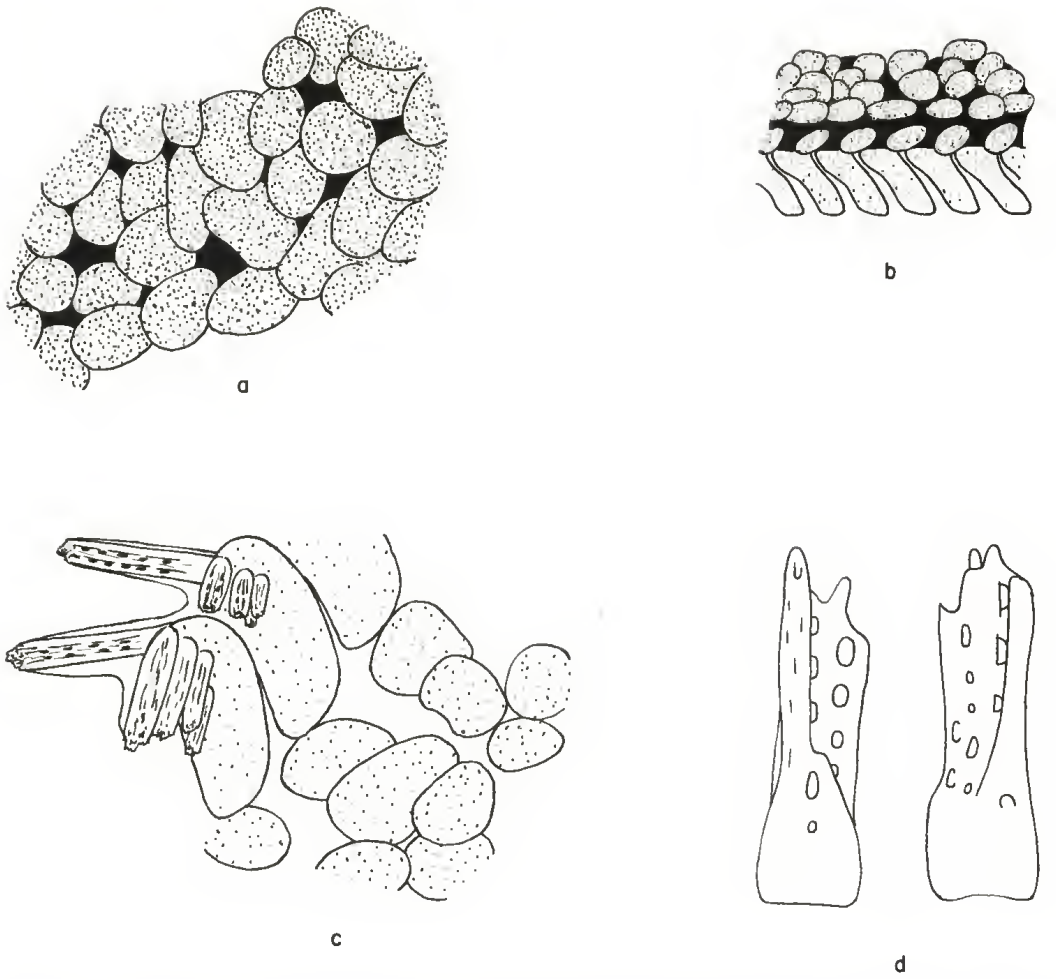

FIG. 59. *Henricia* sp. a, aboral skeletal plates; b, adambulacral and lateral plates; c, adambulacral plates and spines; d, spines from the aboral surface.

A similar specimen, only larger (diameter 150 mm), was examined from the Gulf of St. Lawrence, and several were seen from the Labrador coast and reported (Grainger, 1964) as *H. scabrior*. These may be included in Heding's rather wide concept of *H. scabrior*, and appear to be much like specimens described by him from East Greenland and put provisionally in that species. These individuals seem, however, to form a fairly distinct group and to differ consistently from what is considered here to be the true *H. scabrior*, and for this reason they must be separated from it. They also appear, from the brief description given of it, to resemble Diakonov's (1950) *Henricia knipowitschi* Diakonov, a species reported from the Greenland Sea, the coast of Iceland, and the Barents Sea.

Another specimen, from station 549, is identical to *H. scabrior* in all characteristics but the marginal plates, which are very conspicuous and regular, with spines in groups of up to 6 in number. The diameter is 30 mm, R:r 3.8:1.

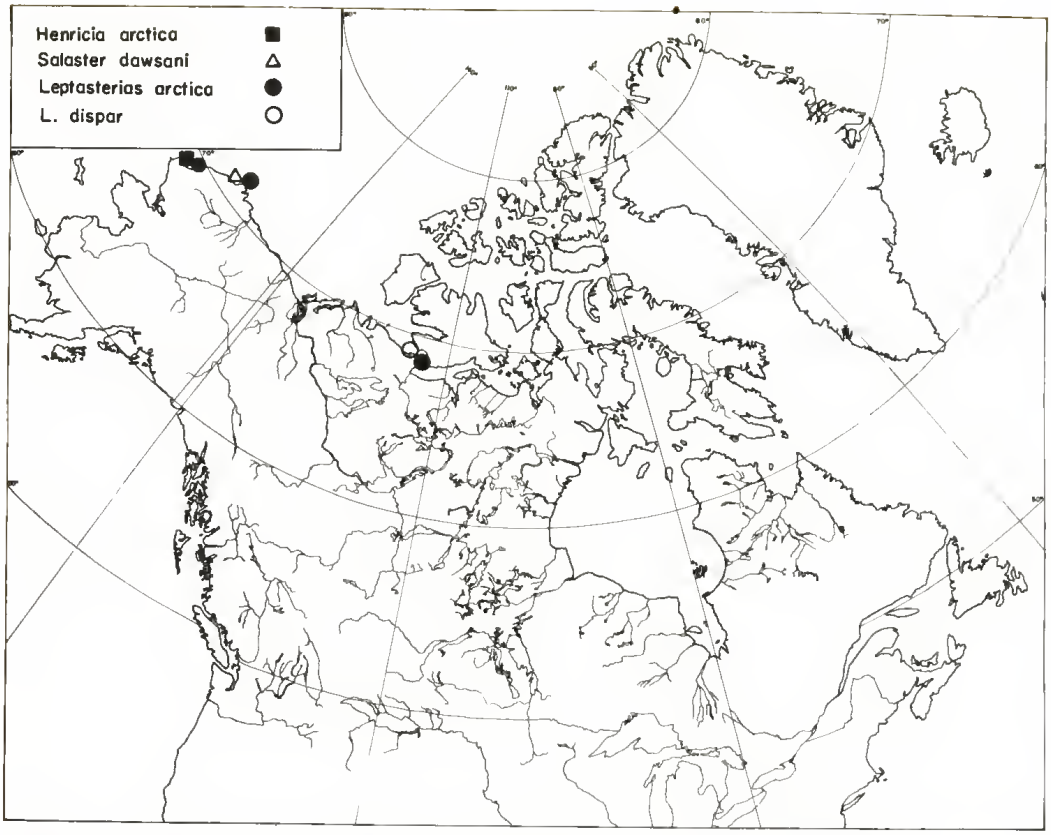

FIG. 60. Northern North American distribution of *Henricia arctica*, *Solaster dawsoni*, *Leptasterias arctica*, and *L. dispar*.

The third, from station 723 (Fig. 59) is perhaps the most distinctive. Its diameter is 27 mm and R:r 3.9:1. The aboral skeleton is irregular and made up of small, circular to ovoid plates, generally imbricated and leaving extremely small and few papular areas. Aboral spines occur usually as groups of 2 to about 6, although they are occasionally single. They are shorter and stouter than in *H. eschrichti* and lack terminal points. Some of the aboral surface plates show regularity, but there are no clearly obvious marginals. The adambulacral plates carry 5 (to 7) spines in single rows, straight except for a slight curve which may be shown by the position of the smallest 2 or 3 spines. A second individual almost identical to this one in its features, but having a diameter of 50 mm and R:r of 3:1, was examined from the Gulf of St. Lawrence.

Order FORCIPULATA

Family PEDICELLASTERIDAE

Pedicellaster typicus M. Sars (Fig. 52)

Pedicellaster typicus Sars, 1861, p. 77, pl. 9(9–17), 10(1–10)
P. palaeocrystallus Duncan and Sladen, 1881, p. 34, pl. 2(22–26)
P. palaeocrystallus Mortensen, 1910, p. 264, pl. 14(1, 9), 15(1, 4, 7)

Usually 5 rays. R:r about 5:1 to 6:1. Aboral plates forming a fairly regular network, with an obvious carinal row and other rows of plates more or less parallel and at right angles to them. Aboral spines single, generally one at each junction of plate rows and often one intermediate along rows. Spines grooved longitudinally, their extremities expanded to form about 3–5 terminal spines. Adambulacral plates usually each with 2 spines, one pointing towards the groove, the other towards the margin. Mouth frame incomplete, the first pair of adambulacral plates of each row not meeting medially. Tube-feet in 2 rows.

This species did not occur in the present collections. The only records from the region considered here (Fig. 52) are from east Ellesmere Island (Duncan and Sladen, 1881) from a rock bottom between 46 and 146 m, and from off Labrador (Mortensen, 1932) from a rock bottom at 314 m (2.8 C). It is a species of the North Atlantic, known from eastern North America to the Kara Sea, and south to about 40°N lat in the west and to about 60°N lat in the east.

Family Asteriidae

Stephanasterias albula (Stimpson) (Fig. 37, 38, 52)

Asteracanthion albulus Stimpson, 1853, p. 14, pl. 1(5)
Stichaster albulus Duncan and Sladen, 1881, p. 29, pl. 2(13–17)
S. albulus Mortensen, 1910, p. 267, pl. 13(1–6), 14(8), 15(8–10), 17(12)
Stephanasterias albula Fisher, 1930, p. 157, pl. 70(1–5), 71(1a–1g), 72(5)

Three to 9 or more rays, often conspicuously unequal in size. Aboral skeleton compact, close-meshed, fairly irregular except for a conspicuously straight row of carinals. Aboral spines small, in close groups of up to 5 or more spines. Adambulacral plates with usually 2 (or 3) spines per plate in transverse rows. Tube-feet in 4 rows. A fissiparous species, specimens with small regenerating rays along with old rays occur as a large proportion of most collections. The number of rays in specimens at hand varies from 3 to 6, with more than two-thirds having 6 rays.

Collection: 41 specimens; 10–90 m; mostly rock, with mud-sand, and mud-rock. Stations: 547, 616, 715, 723, 801, 901a, 61-4, 61-30, 62-4304. Also examined were three specimens collected by Dr D. V. Ellis off southeast Baffin Island in 1953. These originated intertidally at 63°38′N, 68°17′W (Frobisher Bay), floating on *Laminaria* at 62°25′N, 64°54′W (Frobisher Bay) and intertidally at 67°03′N, 62°44′W (Padloping Island). Three additional specimens were present in the W. F. Black collection from Pelly Bay, two taken between 5 and 8 m, and one between 10 and 12 m.

Occurrence in northern Canada is shown in Fig. 52. The depth range in this area is 5–314 m. Most bottoms are of rock, along with mud-sand, mud-rock, and rock-sand. Temperatures range from −1.3 to 2.3 C, salinities from 31.6 to 32.8‰. The species is known in the Atlantic area from eastern North America to the Kara Sea and south to Cape Hatteras and north Norway, and in the Pacific area from the Bering Sea to the Sea of Japan.

Urasterias lincki (Müller and Troschel) (Fig. 34, 39, 40, 51)

Asteracanthion lincki Müller and Troschel, 1842, p. 18
Asterias stellionura Danielssen and Koren, 1884, p. 14, pl. 4(1–9)
A. gunneri Danielssen and Koren, 1884, p. 7, pl. 2, 3(8–9)
A. lincki Döderlein, 1900, p. 200, pl. 4(4–6)

Five rays. R:r at least 4:1 to 9:1. Aboral skeleton delicate, loosely irregular, wide-meshed, consisting of rows of small imbricated plates. Carinals fairly regular. Aboral spines large, smooth, occurring singly. Marginal plates, larger than dorsolaterals, with prominent spines, one on each of the supramarginals and inframarginals. Large conspicuous clusters of very large, crossed, terminally hooked pedicellariae at the bases of the marginal spines, more conspicuous on the inframarginals. Ventrolateral plates usually entirely absent. Adambulacral plates usually with 2 spines per plate. Tube-feet in 4 rows.

Specimens in this collection range from 56 to slightly more than 300 mm in diameter, with R:r from 4.1:1 to 8.3:1.

Collection: 237 specimens; 1–200 m; mostly mud, as well as mud-rock, mud-sand, sand, rock. Stations: 58-36, 58-37, 59-4, 59-6, 59-11, 59-15, 59-26, 59-40, 59-41, 59-42, 59-43, 60-1001, 60-1009, 60-1016, 60-1036, 61-1012, 61-1014, 61-1015, 61-1017, 61-1082, 61-1089, 62-032, 62-033, 62-042, 62-043, 62-1017, 62-1103, 62-1107, 62-3001, 62-3003, 62-7300, 62-7301, 63-004, 63-005, 63-006, 63-008, 63-009, 63-010, 63-012, 63-014, 63-018(b), 63-019, 63-020, 63-032, 63-034. In addition, 15 specimens collected in 1954 and 1955 by S. D. MacDonald were examined. They originated from between 20 and 59 m on mud bottoms near Isachsen, Ellef Ringnes Island, in Slidre Fjord, west Ellesmere Island, and in Mould Bay, Prince Patrick Island.

North Canadian distribution is shown in Fig. 51. It has been taken at between 1 and 200 m in this region, for the most part on mud, and less often on sand and gravel bottoms. Temperatures range from −1.5 to 4.9 C, salinities from 15 to 34‰. It is possibly a circumpolar species, absent from the Pacific but occurring in the Atlantic as far south as New England and north Norway.

Icasterias panopla (Stuxberg) (Fig. 41, 50)

Asterias panopla Stuxberg, 1878, p. 32
A. panopla Danielssen and Koren, 1884, p. 17, pl. 5
A. panopla Döderlein, 1900, p. 204, pl. 4(1), 5(1–2)

Five rays. R:r at least 7.5:1 to 13:1. Aboral skeleton open, irregular, except carinals usually fairly straight. Rays narrow at base, widest about one-fifth to one-tenth of the distance from base to tip, gradually narrowing to a fine point. Aboral spines stout, irregularly placed on the disc. On the rays usually a conspicuous single row of long carinal spines extending from the base to near the end (but not to the end). Dorsolateral spines few, irregularly scattered. On the supramarginal plates, spines, similar to those on the carinals, either singly or in groups of up to 5, form a row; on the inframarginals usually 2 rows. Adambulacral plates each with about 3 spines in transverse rows, those nearest the groove the shortest, those farthest from the groove the longest. Tube-feet in 4 rows.

The largest of these specimens has a diameter of 320 mm, and R:r values range from 8.1:1 to 10:1.

Collection: 18 specimens, 30–185 m; all from mud. Stations: 60-103, 62-043, 62-3001, 63-011, 63-012, 63-014, 63-031, 63-032. Eleven additional specimens collected by S. D. MacDonald were examined. They were collected from between 8 and 81 m depth on soft mud bottoms in Slidre Fjord, west Ellesmere Island, and near Isachsen, Ellef Ringnes Island.

Occurrence in the northern Canadian area is shown in Fig. 50. Depth range is 8–680 m, all bottoms but four of rock and rock-sand are of mud, and reported temperature ranges from –1.5 to 2.8 C, salinity from 32 to 34‰. The species is apparently limited to the area extending eastward from the western Canadian arctic to the west Laptev Sea. A single specimen is recorded from off Hamilton Inlet, Labrador; otherwise the southern limit is along the West and East Greenland coasts, south Spitzbergen, and northernmost Norway.

Leptasterias arctica (Murdoch) (Fig. 36, 43, 60)

Asterias arctica Murdoch, 1885, p. 159
Leptasterias arctica Fisher, 1930, p. 24, pl. 8(5, 5a–h), 9, 10(1–4), 14–16

Five rays. R:r 3.5:1 to more than 5:1. Carinal plates in strongly overlapping irregular rows. Aboral area with usually short (the largest about as broad as high) blunt spines, frequently surrounded by rings of pedicellariae. Lateral plates in more regular longitudinal rows, with generally discernible supramarginal, inframarginal, and ventrolateral spines, the first 2 longer and the first more slender than aboral spines. Sometimes a short intermarginal series. Slender blunt adambulacral spines irregularly 1 or 2 per plate.

This species was not present in these collections. Described by Murdoch (1885) from Point Barrow, Alaska, at 25 m on a rock bottom, and reported by MacGinitie (1955) between 0 and 66 m on rocky bottoms from the same region, it is known from Canadian waters only from Dolphin and Union Strait (Clark, 1920), from a mud and rock bottom at 20–30 m and from a rock-sand bottom at 20–22 m (Fig. 60). It is a North Pacific species, recorded from the Bering and Chukchi seas in addition to north Alaska and western Canada. Diakonov (1950), contrary to Heding's (1935) belief, refers Heding's *L. islandica* (Levinsen) to *L. arctica*. This, if correct, puts *L. arctica* also into the northeast Atlantic region, specifically the Barents Sea and Iceland.

Leptasterias groenlandica (Steenstrup) (Fig. 35, 42, 45, 61)

Asteracanthion groenlandicus Steenstrup, 1857, p. 228
Asterias cribraria Stimpson, 1862, p. 270
Asteracanthion groenlandicum Duncan and Sladen, 1881, p. 27, pl. 3(9–12)
Asterias groenlandica Döderlein, 1900, p. 202, pl. 5(3), 9(5)
Leptasterias groenlandica Fisher, 1930, p. 45, pl. 8(1–3), 21–23, 24(1–2)
L. groenlandica Diakonov, 1950, p. 146, fig. 10, 166–169

Five rays. R:r about 2:1 to 5:1. Aboral skeleton with carinal plates in fairly regular longitudinal rows and dorsolateral plates forming conspicuous parallel, fairly closely-spaced transverse or oblique rows, or with less regular, often winding carinal rows and not so obvious transverse dorsolateral plate rows. Dorsolateral papular areas transversely or obliquely elongate,

often extending from the supramarginals to the carinals. Aboral spines usually small and fairly closely spaced, sometimes cylindrical, more often club-shaped, frequently of uniform size, less often variable, and forming more or less obvious dorsolateral series along the corresponding plate rows. Supramarginal plates with 1–4 spines. Adambulacral plates with cylindrical spines, variable in arrangement, 1 or 2 occurring on each plate, often 1 and 2 alternating on consecutive plates. Adambulacral spines either with or without clusters of pedicellariae. Development of eggs within the stomach.

A distinction is made between *L. groenlandica groenlandica* (Steenstrup) and *L. groenlandica cribraria* (Stimpson). Diakonov (1950) distinguished the two forms as follows:

Leptasterias groenlandica groenlandica (Steenstrup). Aboral skeleton very irregular, carinal row winding and formed of irregularly 3-lobed plates. Aboral spines diversified, usually irregular, less dense than in *cribraria*; spines more or less slender, but of different sizes, usually pointed or slightly club-shaped. On the supramarginal plates usually 2 spines or a single one. Adambulacral plates nearly all with 2 spines, without crossed pedicellariae. *Leptasterias groenlandica cribraria* (Stimpson). Aboral skeleton more regular, in transverse parallel rows along the rays. Carinal rows in 4-lobed plates, arranged along more or less regular longitudinal rows. Aboral spines more dense and uniform than in *groenlandica*, spines small, low, of similar height, cylindrical or more frequently club-shaped. Supra-

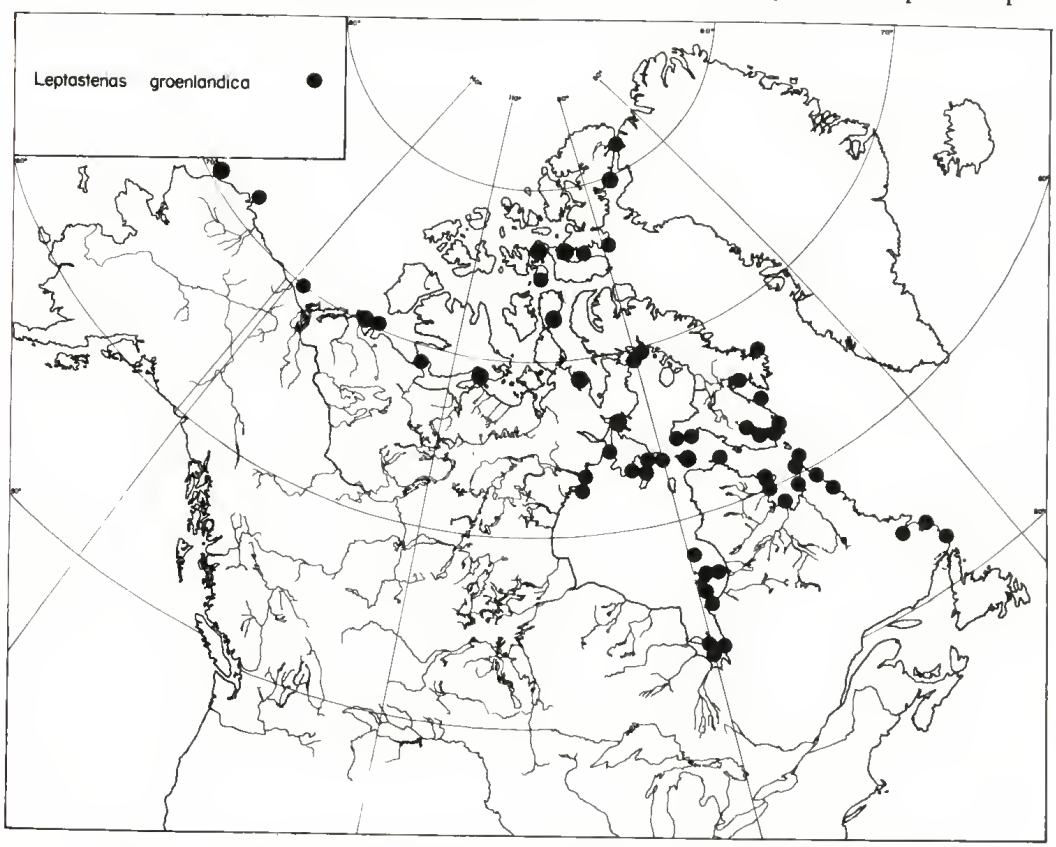

FIG. 61. Northern North American distribution of *Leptasterias groenlandica*.

marginal plates with 3–4 spines. Adambulacral spines proximally 2, farther from the base alternating 1–2 per plate. Crossed pedicellariae fairly numerous, formed in clusters around the spines.

Collection: 156 specimens; 0–189 m; rock, rock-gravel, rock-sand, rock-mud, sand-mud, mud. Stations: 512, 533, 542, 547, 549, 552, 611, 613, 616, 715, 716, 719, 720, 723, 817, 818, 821, 822, 901c, 58-3, 59-2, 59-4, 59-20, 59-22, 59-33, 59-50, 60-1013, 61-5, 61-12, 61-21, 61-43, 62-042, 62-049, 62-2017, 62-4003, 62-4006, 62-4015, 62-4300, 62-4303, 62-4304, 62-7305, 63-004, 63-009, 63-032. Two specimens were present in the collections of the *Cancolim II*, taken from a sandy bottom, 2–5 m deep, off the north point of Parry Peninsula (Amundsen Gulf). Three specimens occurred in the D. V. Ellis collections, taken intertidally at 63°24′N, 67°49′W, Frobisher Bay, floating on *Laminaria* at 62°51′N, 64°49′W, Frobisher Bay, and intertidally at 67°03′N, 62°44′W, Padloping Island. One specimen was included in the W. F. Black collection from Pelly Bay, taken between 4 and 8 m depth.

North Canadian distribution is shown in Fig. 61. Depth range is from 0 to 225 m. Temperatures range from –1.4 to 5.7 C, salinities from 20 to 33‰. It is evidently a circumpolar species, reaching as far south as New England, Iceland, and north Norway in the Atlantic area, and the Bering Sea in the Pacific area.

Leptasterias floccosa (Levinsen) (Fig. 33, 44)

Asterias mülleri floccosa Levinsen, 1887, p. 392
Leptasterias floccosa Heding, 1935, p. 55, fig. 19(4–6), 20(2)
L. floccosa crassa Heding, 1935, p. 54, fig. 19(7–8), 20(4)

Five rays. Rays short and thick. Aboral and lateral skeleton rather an open meshwork, with large carinal and supramarginal plates in regular rows, irregularly arranged dorsolaterals, and an even row of inframarginals and ventrolaterals. Aboral and lateral spines, usually 2 or 3 per large plate, small and slender, scattered more or less evenly over the rays.

The form *crassa* Heding is only vaguely distinguished from *floccosa* by Heding (1935, pp. 54–55). It is suggested as possibly being a southerly form of *floccosa* (known from Baffin Bay and northeast Greenland), and is recorded from the southern parts of West and East Greenland (Heding, 1935, 1936).

Not found in the present collections and not recorded as such from west of Baffin Bay and Davis Strait, specimens of this species may have been identified formerly as *L. mülleri* (Sars) from the Canadian Archipelago and waters to the south. Fisher (1930) suggested that records of *L. mülleri* from New England and southeast Canadian waters probably referred instead to *L. tenera* and allied forms, while records of *L. mülleri* from the "arctic" (Greenland, Spitzbergen, Siberian Sea) probably referred to *L. hyperborea*. Heding (1935) concluded that *L. hyperborea* was confined to the northeast Atlantic area and along with *L. mülleri* was absent from Greenland. He recognized that his *L. floccosa crassa* was much like the Norwegian *L. mülleri*, but declared that the differences described were significant. The major distinctions between the two forms, he stated, were the presence of secondary spines on the carinals and at least the upper ventrolaterals in *L. floccosa* and the presence of only single spines in *L. mülleri*.

Leptasterias polaris (Müller and Troschel) (Fig. 46, 62)

Asteracanthion polaris Müller and Troschel, 1842, p. 16
A. polare Duncan and Sladen, 1881, p. 23, pl. 2(4–8)
Leptasterias polaris Fisher, 1930, p. 60, pl. 30(1–2), 32(3), 35
L. polaris acervata Fisher, 1930, p. 62, pl. 30(3–5), 31, 32(1–2), 33(7), 36(2–3), 37–40

Usually 6 rays. R:r at least 3.5:1 to 6.3:1. Aboral surface a strong, fairly close-meshed network, with spines which vary greatly in size, shape, and arrangement in the different reported subspecific forms. Aboral spines, generally of stout construction, frequently with bulbous ends (although in some they may be relatively longer and cylindrical to the tip), and often in groups of several small spines surrounding a larger central one, or less frequently as solitary spines of varying density. Not infrequently aboral spine groups with some semblance of regularity along the carinal rows at least, and sometimes additionally in one dorsolateral row longitudinally along either side of the carinals; elsewhere usually scattered. Marginal and ventrolateral spines cylindrical and longer and relatively more slender than the aborals, in 3 or 4 conspicuously regular longitudinal rows along much of the length of the rays. Adambulacral spines, cylindrical, relatively more slender and shorter than the lateral spines, frequently as 2, less often as 1 per plate. Sometimes long consecutive series of 2-per-plate pairs of spines alternate regularly in position giving superficially the impression of 4 rows of spines along each side of the groove.

As shown above, *L. polaris* is a highly variable species, and there is a considerable lack of clarity among the subspecific forms which have been described. In the western Atlantic area *L. polaris polaris*, the "northern" and *L. polaris borealis*, the "southern" form, only vaguely distinguished on the basis of pedicellariae, appear to occupy a region extending from New England northeast to Greenland (east of which as far as the New Siberian Islands no *L. polaris* in any of its forms is known) and west to at least Cornwallis Island. Among West Greenland specimens, Fisher (1930) distinguished two forms, *L. polaris polaris* and *L. polaris subacervata*, the first with uniform spines showing no evident aggregation into groups, the second with some spines noticeably enlarged and combining with other spines in convex groups. The form *polaris*, it was pointed out, may be considered as the equivalent of the western form *aphelonota*, the form *subacervata* the equivalent of the western form *acervata*. In the North Pacific and arctic areas to the north, a number of forms, many of them evidently intergrading, have been proposed (see Verrill, 1914; Fisher, 1930). Fisher used the designation *L. polaris acervata* (Stimpson) as the polymorphic representative of *L. polaris* inhabiting the North Pacific, Bering Sea, and adjacent parts of the Arctic Ocean. Included were three forms, *aphelonota*, *acervata*, and *polythela*, distinguished chiefly by their aboral spines. Diakonov (1950) added to the *acervata* complex the form *intermedia* and also included *L. polaris ushakovi* Diakonov, both from eastern Russian seas.

Stimpson's (1862) diagnosis of *Asterias acervata* (= *L. polaris acervata acervata*) did not distinguish clearly this western form from the Atlantic *polaris*, pointing out only such vague differences as the rays being more convex and more tapering and the aboral spines more numerous and crowded in *acervata* than in *polaris*. According to Verrill (1914, p. 111): "Stimpson's description applies fairly well to some specimens of the same size from the Atlantic, except in one particular." This feature is the straight pedicellariae, which on the lateral surfaces of the rays are said to be much larger in *acervata* than in *polaris*. Fisher (1930, pl. 32) showed

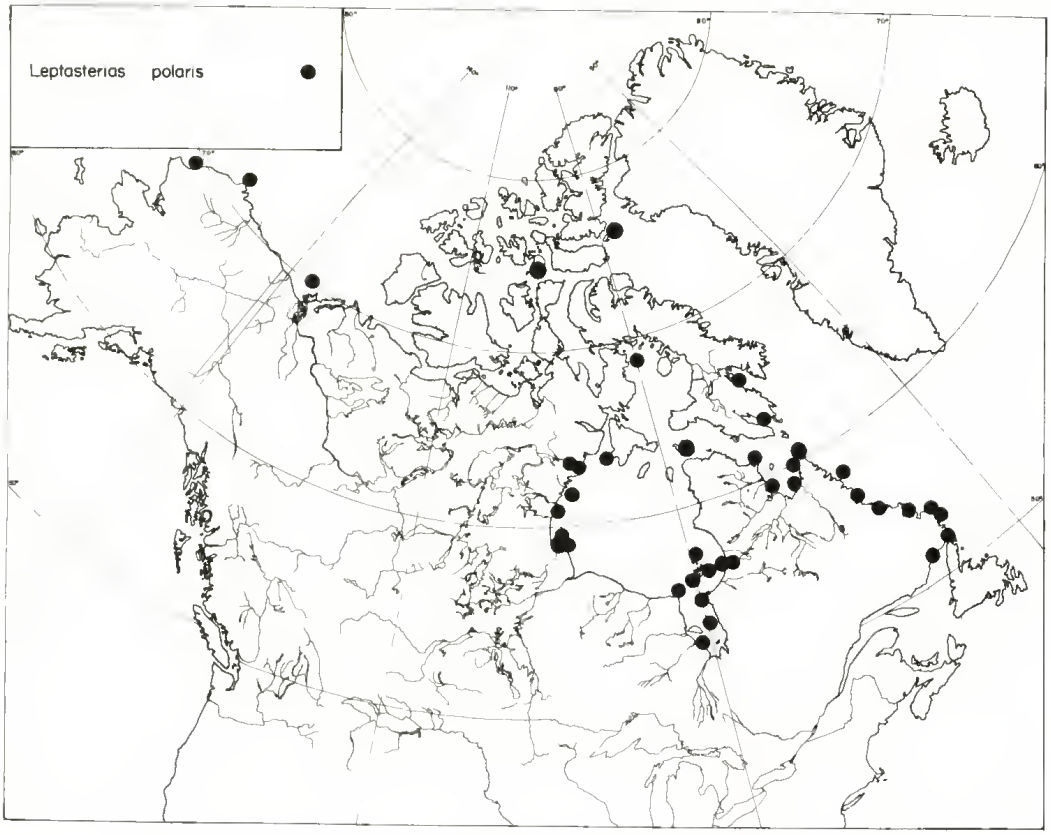

FIG. 62. Northern North American distribution of *Leptasterias polaris*.

straight, intermarginal pedicellariae of 0.58 mm maximum length from a very large Atlantic *L. polaris borealis*, and comparable pedicellariae as long as 1.2 mm from the Alaskan *L. polaris acervata acervata*. The consistency of this distinction, especially in comparing specimens from water of similar temperature on both sides of the continent, remains to be demonstrated conclusively. Murdoch's (1885) and MacGinitie's (1955) material from Point Barrow, Alaska (referred to *L. polaris acervata*) is not described in detail. Clark's (1920) reference to *Asterias acervata borealis* Perrier, from northwest Alaska, referred by Fisher (1930) to *L. polaris acervata*, was presumably a result of Clark following Verrill's suggestion of using *A. acervata borealis* rather than *A. polaris* (which name Verrill concluded to be preoccupied) for the North Atlantic form. It appears therefore as if Clark agreed with Verrill's conclusion that no consistent difference could be found between the Atlantic and at least some of the western individuals, and so designated his specimen according to the Atlantic rather than the western name.

The present western specimens (from Herschel Island) number only 2, one 238 mm in diameter with R:r 5.0:1, the other 234 mm in diameter with R:r 5.3:1. The largest straight lateral pedicellariae are about 0.9 mm long, slightly longer therefore than any found in the eastern material where the maximum was about

0.7 mm, and the aboral spines are possibly slightly less dense than in eastern specimens; both features, however, may be related to difference in size, the western specimens being considerably larger. Verrill (1914), emphasizing the similarity between the eastern and some western individuals, implied that geographical separation was perhaps the strongest factor of distinction between *polaris* and *acervata*. This separation has now been rather markedly reduced, with demonstration here of the occurrence of the species in north Foxe Basin and at Cornwallis Island. There is certainly less reason now than before to believe that a real distributional gap between the western and eastern representatives exists, although northern Canadian waters from about 95° to about 135°W have not so far been shown to support the species.

Collection: 33 specimens; 6–100 m; mostly rock, also rock-sand, mud-rock, and mud. Stations: 818, 901a, 58-3, 58-4, 58-32, 59-2, 59-29, 59-50, 59-54, 59-57, 59-64, 60-1009, 61-3, 61-4, 61-5, 61-11, 61-13, 61-17, 62-4003, 62-4006, 62-4011.

Occurrence in north North American waters is shown in Fig. 62. Depth range is 0–110 m, bottoms for the most part of rock as well as of rock-sand, mud-rock, and mud. Temperatures at collection stations are between −1.7 and 4 C, salinities 20 and 33‰. General distribution of the species, in its broad sense, is from the Bering Sea eastward to East Greenland and southward in the west Atlantic to New England.

Clark (1940, p. 430, pl. 59) described *Leptasterias bartletti* from between Cape Alexander and Cape Chalon (about 78°N lat), northwest Greenland, from a rocky bottom between 46 and 73 m deep. Apparently only a single small, 6-rayed specimen, with R 25 mm and R:r 3.1:1, was found. From the description given, it is not readily distinguishable from *L. polaris*.

Leptasterias dispar Verrill (Fig. 60)

Leptasterias (?) *dispar* Verrill, 1914, p. 142, pl. 16(7)
L. camtschatica dispar dispar Fisher, 1930, p. 97, pl. 42(4, 4a–b), 49(4–6)

Six rays. R:r usually about 4:1. Aboral surface of relatively large, closely spaced plates with conspicuous large, stout carinal spines with finely striated, bulbous tips up to nearly 2 mm in diameter. Spines typically in groups of 2–5, usually forming evident but irregular rows. Dorsolateral spines smaller. Supramarginal, inframarginal, and ventrolateral spines variably in 1 or 2 rows each, prominent, the lower spines the largest. Adambulacral spines, variably 1 or 2 per plate, about half the length of the ventrolaterals. *Leptasterias dispar* has usually a relatively larger disc, stouter rays, more dense and larger aboral spines and longer supramarginal spines than *L. polaris*.

Within the present region this species is known only from Dolphin and Union Strait (Fig. 60), from a bottom of mud and rock, 20–30 m deep (Clark, 1920). It is known elsewhere from the North Pacific and Bering Sea, but not so far from north Alaska or the Chuckchi Sea.

DISTRIBUTION AND ECOLOGY

Northern North American Waters

In the discussion of the distribution ranges of the various species, the terms arctic, subarctic, and boreal are used as defined by Dunbar (1951). The regions so defined are shown in Fig. 63 (from Dunbar, 1953, with minor changes).

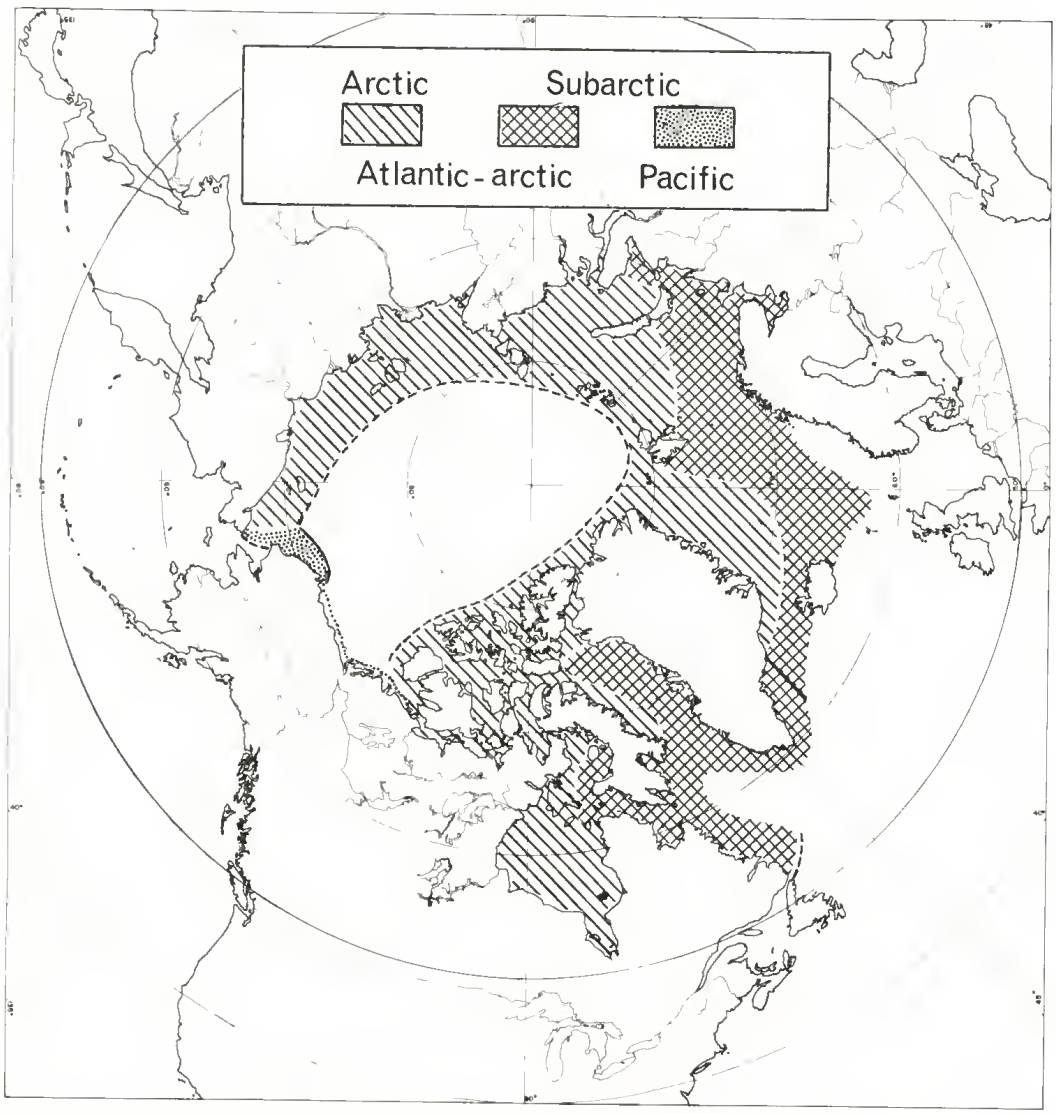

FIG. 63. The limits of the arctic and subarctic, and of the Atlantic and Pacific faunal regions.

TABLE II. Collection stations, 1953–1962.

Station	Location	N lat	W long	Depth	Bottom
				m	
512	North Hudson Bay	63°27′	84°08′	21	rock
533	Hudson Strait	64°14′	76°35′	12	–
542	"	62°24′	77°56′	13	–
547	North Hudson Bay	63°41′	80°12′	73	rock
549	"	63°36′	82°00′	73–75	rock
552	Chesterfield Inlet	63°19.5′	90°42′	18–25	–
611	North Hudson Bay	62°59.7′	82°39′	49	rock, mud
613	"	62°57.2′	81°50′	162–189	rock
615	"	63°15.5′	83°43′	18–36	rock
616	"	63°15.5′	83°41′	85–90	rock
711	Repulse Bay	66°28′	86°12′	90–100	rock
713	Foxe Basin	66°55′	81°20′	25–37	rock
715	"	69°34′	80°17′	14–15	mud, sand
716	"	69°23′	80°49′	110	rock
718	"	69°18.5′	81°35.5′	75	mud
719	"	69°20.5′	81°43.5′	52	mud
720	"	69°21.5′	81°40.5′	2–9	mud
722	"	69°20′	82°00′	36–45	mud
723	"	69°22.7′	81°44.3′	20–22	mud
801	"	69°20.5′	81°26′	10	rock
811	"	69°37.2′	81°06.3′	110	rock
815	"	69°43.2′	82°07′	70–80	rock
817	"	69°36′	80°13′	20	rock
818	"	69°24′	80°53′	93	rock, mud
820	"	69°55.7′	80°19′	73	mud
821	"	70°00.5′	80°12′	13–30	mud
822	"	69°27.2′	80°26.5′	29	rock
828	"	69°25.7′	78°33′	27	rock
832	"	69°44′	77°38.2′	80–90	rock, sand
837	"	69°16′	77°48′	55	rock, sand
901a	"	69°06′	79°11′	22	rock
901b	"	69°06′	79°11′	22	mud
901c	"	69°06′	79°11′	29	mud
901d	"	69°06′	79°11′	35	rock
901e	"	69°06′	79°11′	50	rock, mud
58-3	Southeast Hudson Bay	56°25.5′	78°55.5′	6–7	rock
58-4	"	56°25.5′	78°54′	17	–
58-21	North Hudson Bay	62°36′	78°16′	53	rock
58-28	East Hudson Bay	59°04′	80°27′	115	rock, mud
58-32	Southeast Hudson Bay	57°31′	79°41′	12	rock
58-36	"	55°47.5′	79°11′	90–100	mud, rock
58-37	"	55°15′	79°30′	120–125	mud, sand
59-1	James Bay	51°30′	80°16′	9	mud, rock
59-2	"	52°00′	80°00′	23	rock
59-4	"	52°28′	80°02′	60	rock, sand
59-6	"	52°55′	79°58′	65	sand, mud, rock

(*Continued*)

TABLE II. Collection stations, 1953–1962. — (*Continued*)

Station	Location	N lat	W long	Depth	Bottom
				m	
59-11	James Bay	52°17′	78°50′	22	mud, rock
59-15	"	53°56′	79°52′	55–50	mud, rock
59-20	Southeast Hudson Bay	56°27′	78°31′	50	rock
59-22	"	56°32′	77°27′	38	mud, rock
59-26	"	55°23′	77°40′	90	mud
59-29	"	55°50′	80°15′	40	rock
59-33	"	55°35′	79°20′	60–70	rock
59-35	"	55°19′	79°12′	205	mud
59-37	"	55°00′	78°59′	125	mud, rock
59-38	Richmond Gulf	56°09′	76°26′	95–130	mud
59-40	"	56°18′	76°17′	42–46	mud
59-41	"	56°26′	76°20′	60	mud
59-42	"	56°27′	76°22′	9–27	mud
59-43	Southeast Hudson Bay	56°11′	76°42′	120	mud
59-50	"	58°00′	79°38′	50–60	rock
59-54	"	56°23.5′	78°52.5′	15	rock
59-57	"	54°42′	79°59′	32	gravel, rock
59-64	"	55°13′	82°08′	26	gravel
59-69	"	56°16′	81°42′	126	sand, mud, gravel
59-70	"	56°15′	81°14′	140	mud
59-71	"	56°13′	80°44′	73	sand, mud, gravel
59-72	"	56°11.5′	80°14′	95	mud
60-103	Ellef Ringnes Island	78°46′	103°29′	30	mud
60-1001	South Beaufort Sea	69°32.5′	138°55′	13–35	mud
60-1009	"	69°31′	138°50′	18–27	mud
60-1013	"	69°38′	138°35′	92–137	sand
60-1016	"	69°37′	139°57′	10–13	gravel
60-1036	"	69°32′	138°57′	22–44	mud
61-1	Northwest Hudson Bay	60°24′	93°55′	60	rock, mud
61-2	"	61°00′	93°49′	45	rock
61-3	"	61°05′	93°54′	18–20	rock
61-4	"	61°52′	92°20′	40	rock
61-5	"	62°30′	91°05′	70	rock
61-10	Chesterfield Inlet	63°43′	91°43′	80	rock
61-11	"	63°39′	91°27′	20–70	rock
61-12	"	63°33′	91°02′	90–100	rock
61-13	"	63°21′	90°37′	95–100	rock
61-17	Roes Welcome Sound	63°37′	87°33′	46	rock
61-21	"	64°43′	86°57′	79	rock
61-24	"	65°07′	86°45′	46	rock
61-26	"	65°24′	86°44′	75	rock
61-28	"	65°22′	86°13′	47	rock
61-30	"	65°59′	85°45′	57	rock
61-32	Foxe Basin	66°11′	84°12′	145	mud, rock
61-36	Frozen Strait	65°32′	83°55′	285	mud, rock
61-39	Duke of York Bay	65°32′	84°52′	42	mud, rock
61-42	Frozen Strait	65°56′	84°36′	170	–
61-43	"	66°13′	85°09′	92	–

(*Continued*)

TABLE II. Collection stations, 1953–1962. (*Concluded*)

Station	Location	N lat	W long	Depth	Bottom
				m	
61-1012	Liverpool Bay	69°56′	128°53′	1–2	sand
61-1014	"	70°02′	128°42′	9	sand
61-1015	"	70°11′	128°35′	11	sand, mud
61-1017	"	70°23.6′	128°49′	12–13	mud
61-1032	"	69°35.5′	131°10′	30	sand
61-1082	South Beaufort Sea	70°13′	132°36′	29–33	mud
61-1089	"	69°25.6′	132°59.1′	9–20	mud
62-032	Liverpool Bay	69°48′	130°19′	10	mud, sand
62-033	"	69°56′	129°08′	9	mud
62-042	Amundsen Gulf	70°11.4′	127°03′	68	mud
62-043	"	70°06.6′	125°43′	110	mud
62-049	"	70°07′	124°39′	15	mud
62-1017	M'Clure Strait	74°17′	120°00′	c. 50	mud
62-1103	Prince of Wales Strait	72°53′	118°01′	5	mud
62-1107	"	72°53′	118°01′	16–0	mud
62-1108	"	72°53′	118°01′	50	mud
62-2008	East Somerset Island	72°45.5′	94°04.5′	30–40	sand, mud
62-2012	"	72°44.6′	94°05′	36	clay, mud
62-2017	"	72°46.3′	93°55′	11–24	sand
62-2030	"	72°46.3′	93°55′	24–27	clay
62-2031	"	72°46.5′	94°13′	40	clay, mud
62-3001	Slidre Fjord	80°00′	86°00′	2–45	mud
62-3003	"	79°58′	85°35′	8	mud
62-4001	South Cornwallis Island	74°36′	94°13′	35	–
62-4003	"	74°37.5′	94°12′	25	rock, sand
62-4006	"	74°39.1′	94°15.7′	15	mud, rock
62-4011	"	74°37.8′	94°18.3′	18	–
62-4015	"	74°38.2′	94°18.7′	–	–
62-4300	West Devon Island	76°37.2′	96°21.6′	5–0	–
62-4303	"	76°37.1′	96°24.9′	5–0	rock
62-4304	"	76°37.3′	96°27.8′	25–0	–
62-4305	"	76°37′	96°27.4′	40–0	–
62-7300	South Victoria Island	69°10′	106°20′	30	sand, mud
62-7301	"	69°10′	106°20′	30+	mud
62-7305	"	69°10′	106°20′	20–30	rock, gravel
63-004	Amundsen Gulf	70°06′	125°09′	60	mud
63-005	"	70°02.5′	125°26′	91	mud
63-006	"	70°03.7′	126°00′	182–200	mud
63-008	"	69°25.6′	125°48.5′	18	mud
63-009	"	69°39.3′	125°22.3′	14	mud
63-010	"	69°39.3′	125°22.3′	49	mud
63-011	"	70°05.8′	126°02.5′	185	mud
63-012	"	70°03.9′	125°28.5′	80	mud
63-014	"	70°17.9′	123°55′	170	mud
63-017	"	70°11′	124°16.8′	65	mud
63-018(a)	"	70°10.5′	124°30′	14	rock
63-018(b)	"	70°09.4′	124°30′	27	rock
63-019	"	69°49.7′	123°05.5′	83	sand, gravel
63-020	"	69°39.3′	123°33.3′	52	sand, gravel
63-031	"	70°16′	125°42.5′	174	mud
63-032	"	70°14.3′	124°34.4′	71–73	mud
63-034	"	70°14′	124°36.5′	73	mud

Distributions of the species considered here, within the geographical area under discussion, are shown in maps above. From the figures it is apparent that there are several quite distinct patterns of occurrence. Two species, *Solaster papposus* and *Leptasterias groenlandica*, extend over the whole of the area of the collections and originate from far more stations than any of the other species taken (Fig. 56, 61). They occurred over a wide range of temperature and salinity conditions (Fig. 64a), and originated in large numbers on both hard and soft bottoms (Table II). Both species are circumpolar, range from the Arctic Ocean to boreal waters (Fig. 65a), occur over their full range from the shore to about 1200 and 800 m depth, respectively, and inhabit the upper water layers (those showing the greatest seasonal temperature and salinity fluctuations) everywhere within their range. They appear to be the best adapted of all the species considered to the full range of the waters treated here.

Ctenodiscus crispatus, also widely spread over the northern Canadian area, was found at fewer stations than the species above (Fig. 47). Temperature and salinity conditions for this species were more restricted, colder and more saline, than above (Fig. 64b), minimum depths were similarly shallow (2 m), and bottoms on which the species was found were of various kinds but principally soft. The last feature without doubt contributed most to the more scattered occurrence in these waters. Circumpolar and reaching from Arctic Ocean to boreal waters, this species more or less shares the horizontal distribution pattern of the two species above (Fig. 65a). Its overall depth range however is 2 to about 1900 m, and its occurrence in near-surface waters is largely limited to the northern portion of its range (northern North America, Greenland, Spitzbergen, north Siberian waters). Farther south it is reported from deeper (colder) waters only. Although response to temperature and salinity may restrict habitation of very shallow waters in northernmost Canada (as presumably it limits the species to deep water only in the southern part of its range), the substrate would appear to be the chief limiting factor to horizontal occurrence in the region considered here.

Pteraster militaris is restricted in the present material to the eastern half of northern North America (Fig. 52). It is primarily a hard-bottom species. Apparently not quite circumpolar, it is not known from between Bering Strait and the central Canadian arctic. Like all the species named above, it is known from the Arctic Ocean to boreal waters. Like *C. crispatus* it is taken in shallow water only in the north and is found deeper (to about 1000 m) in the south. The nature of the bottoms inhabited, however, separates the two species almost completely. While the conditions of temperature and salinity and the depths at which it is found in the eastern part of North America would not appear to prevent its occurrence in the western part of the region, it is suggested that its absence from collections from most of the arctic islands and the western mainland coast may be a result of the kinds of substrate sampled there; in fact the almost exclusively soft bottoms of the central north and west may account for the absence of the species from collections made in those waters. *Pteraster pulvillus*, restricted here to the southeast part of the area only (Fig. 49), was found within still narrower temperature-salinity limits (Fig. 64c),

also mostly on rocky bottoms, but only between about 40 and 150 m. It is known from the Arctic Ocean only to the subarctic and is apparently absent from the Chukchi Sea to eastern Canada. It appears to be absent from very shallow water everywhere.

Urasterias lincki, found in the present material in the northwest and southeast parts of the area (Fig. 51), occurred over a fairly wide temperature and a very wide salinity range (Fig. 64d). It is a species with wide substrate tolerance, although favouring mud. Possibly circumpolar, it extends from the Arctic Ocean to subarctic waters (Fig. 65b), occupies an overall depth range of 0 to only about 550 m, and occurs near the surface only in the arctic (being found usually deeper in the southern subarctic). It appears to be adapted to low salinity (as low as at least 15‰) at relatively high temperatures, and is thus especially successful in the shallow waters of such low-salinity, soft-bottom areas as Liverpool Bay, south James Bay, and Lake Melville, where it was found in large numbers. At relatively high salinity it was found chiefly in very cold water. These factors and, it is suggested, the distribution of soft bottoms especially, may account for its rather peculiar pattern of occurrence. A similar distribution is shown by *Poraniomorpha tumida* (Fig. 51) which, however, showed a narrower salinity and temperature range (Fig. 64d). It too is a predominantly soft-bottom form. It is found deeper in the south (to 1200 m) than in the north. It is probable that factors similar to those limiting *U. lincki* give it a very similar range within the present region.

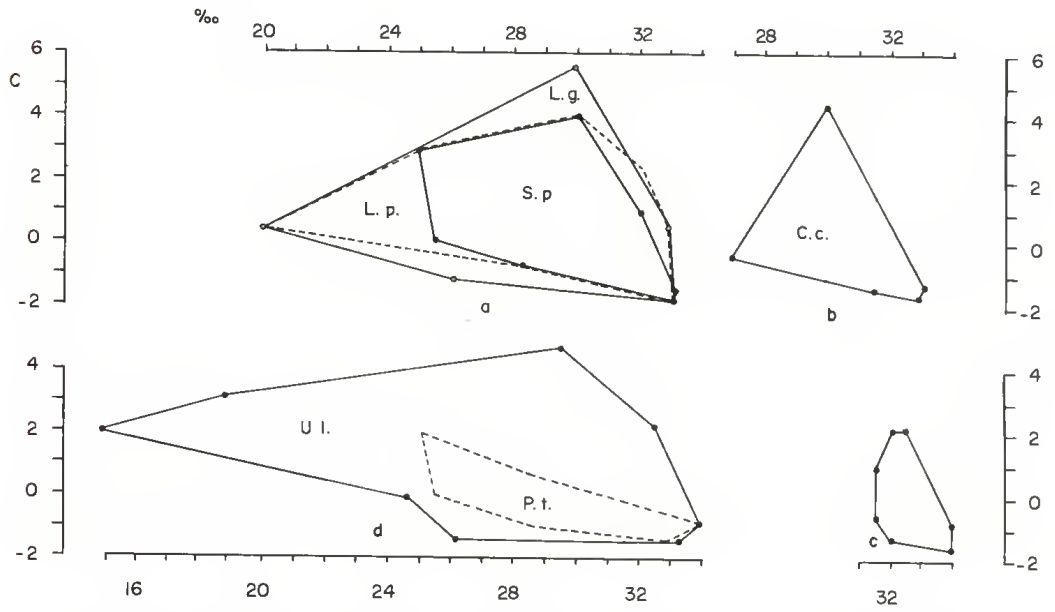

FIG. 64. Temperature-salinity diagrams from stations at which (a) *Solaster papposus*, *Leptasterias groenlandica*, and *L. polaris*, (b) *Ctenodiscus crispatus*, (c) several species (see text), and (d) *Urasterias lincki* and *Poraniomorpha tumida* were collected.

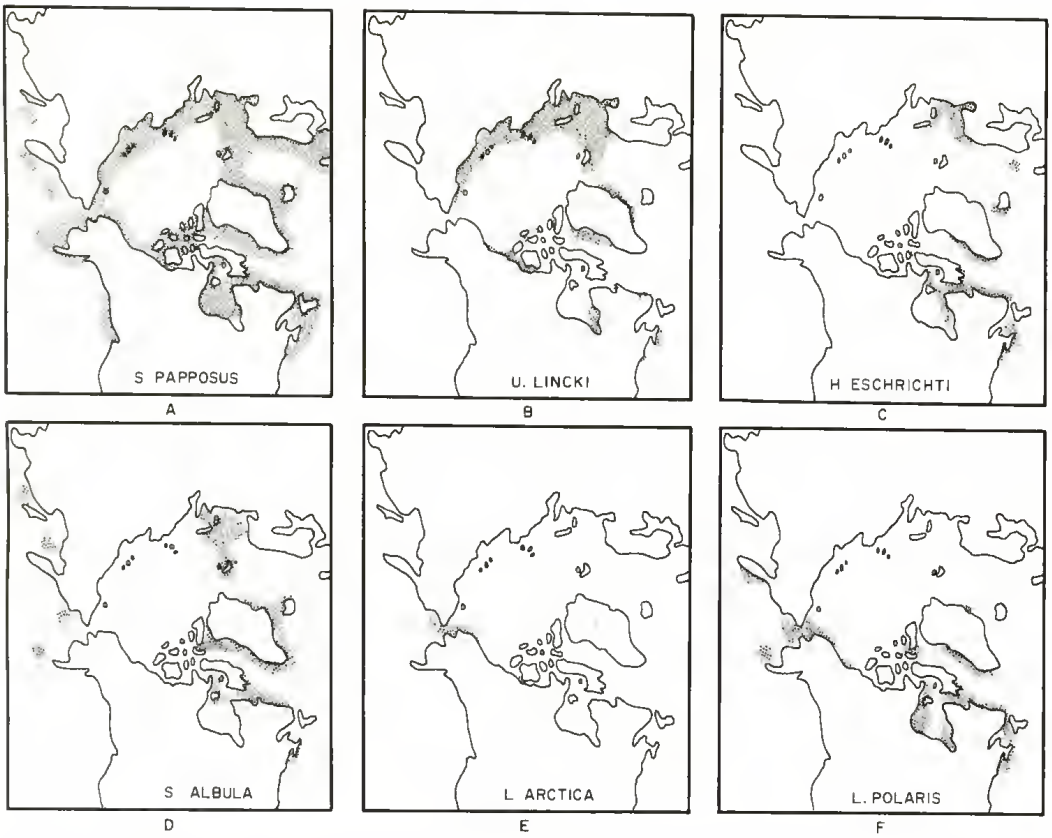

FIG. 65. Total distribution of (a) *Solaster papposus*, (b) *Urasterias lincki*, (c) *Henricia eschrichti*, (d) *Stephanasterias albula*, (e) *Leptasterias arctica*, and (f) *Leptasterias polaris*.

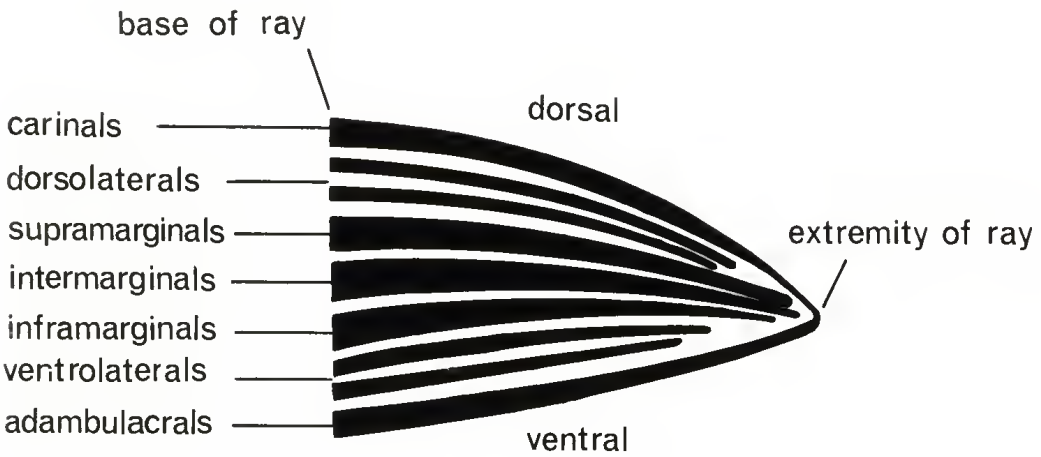

FIG. 66. Diagrammatic representation of the skeletal plate rows of a sea star ray, seen from the side.

Two other generally mud-bottom species, *Icasterias panopla* and *Pontaster tenuispinus*, occurring predominantly in the northern part of the present area (Fig. 50), appear to have relatively narrow temperature–salinity boundaries. They both range from northwest Canada eastward to the Siberian coast, the first ranging from Arctic Ocean to subarctic waters between about 2 and 900 m, the second from Arctic Ocean to boreal waters between about 18 and 2000 m; both occur deeper in the south than in the north. Both species would appear to be limited largely to the northern soft-bottom region of the Canadian area as a result of suitability of substrate and fairly low bottom temperatures and relatively high salinities; they are excluded from the more southerly soft-bottom regions inhabited by *U. lincki* and *P. tumida* by the lower salinities found there.

Poraniomorpha bidens and *Hymenaster pellucidus*, both mud-bottom forms, are recorded only from the northeast and west parts of the present region (Fig. 48), from waters of less than O C and more than 33‰ salinity. Both species were reported formerly from Lancaster Sound in the region west of Baffin Bay and from there eastward to the Siberian coast, from between 50 and 1200 and 15 and 2800 m, respectively; they are found only at great depth in the southern parts of their ranges and usually at considerable depth elsewhere. The present find of both species in deep western arctic water suggests that both may be circumpolar in fairly deep water along the fringes of the Arctic Ocean. Neither species appears to penetrate far into the relatively shallow waters of the Canadian Archipelago. *Bathybiaster vexillifer* (Fig. 48), another mud-bottom species, is known so far in the present region only from the Lancaster Sound location of the two species above. It occupies a similar range in the waters of and immediately adjacent to the North Atlantic, although it is evidently restricted to a somewhat greater depth (200–2200 m), and it may ultimately be shown also to have a circumpolar range around the periphery of the Arctic Ocean.

Solaster syrtensis and *Henricia scabrior* (Fig. 49) were found in the eastern part only. Temperature and salinity limits are narrow (Fig. 64c) and the bottoms on which they were found are chiefly hard. They are known from waters adjacent to the North Atlantic and north of Siberia only, from the Arctic Ocean to the subarctic, and near the surface in the north only.

Stephanasterias albula is another species limited to eastern Canadian waters (Fig. 52), and found nearly always on hard bottoms. It appears to be predominantly a species of the Atlantic area, but is recorded too from the Bering Sea and the Seas of Okhotsk and Japan, but not from the intermediate waters of north Siberia or northwest Canada (Fig. 65d). It appears to be primarily a subarctic species of the upper waters over all of its Atlantic range. *Leptychaster arcticus*, reported only off the Labrador coast (Fig. 49) on a rocky bottom, is another species of the Atlantic and Pacific areas evidently absent from the waters between. It is a subarctic-boreal form and the species most characteristic of warm water of those considered here. Two other subarctic species, known only from the eastern portion of the present

area and from the general Atlantic area, are *Henricia eschrichti* (Fig. 49, 65c) and *Pedicellaster typicus* (Fig. 52), the first recorded from both hard and soft bottoms, the second only from rock.

Solaster endeca and *Pteraster obscurus* are reported from both the eastern and western portions of the region (Fig. 53). Both are predominantly hard-bottom forms with narrow temperature and salinity ranges. Both are Atlantic and Pacific species and both range from the fringes of the Arctic Ocean to boreal waters, being found usually deeper than 25 m everywhere. *Lophaster furcifer* (Fig. 52) is also reported from both the eastern and western parts of the region. It is a predominantly hard-bottom species. Known from north of the Atlantic and off Siberia, from the Arctic Ocean to the subarctic, and in near-surface waters in the northern part of its range only, it may be represented in the Pacific by the forms *L. furcilliger* and *L. furcilliger vexator*.

Leptasterias polaris occurs on both hard and soft bottoms of the western and eastern parts of the area, and possibly in the waters between (Fig. 62). Temperature and salinity limits are wide (Fig. 64a). It is a species of the Pacific which evidently has extended its range eastward to the northwest Atlantic (Fig. 65f). Its occurrence between the western and eastern portions of the present area, as shown here, is unknown; however, its apparently limited tolerance of soft bottoms suggests that it is continuously distributed at least across the southern part of the central arctic area.

Leptasterias arctica and *L. dispar* (Fig. 60, 65e) are Pacific species which appear to have moved east from Bering Strait and north Alaska to at least the Amundsen Gulf area. Evidently absent from west of Bering Strait they are the only two species here limited to the Pacific, north Alaskan, and western Canadian region.

Two species not mentioned above are shown in Fig. 60 to complete reference to the known sea star fauna of northern Alaska. They are *Henricia arctica* Verrill, reported by Verrill (1914) and known also from the Bering Sea, and *Solaster dawsoni arctica* Verrill, also reported by Verrill (1914) and recorded from the north Pacific, Japanese, Okhotsk, Bering, and Chukchi seas. Neither of these appears to have been taken as far east as Point Barrow, Alaska.

Table III shows associations of species in about 280 collections from northern Canada, giving the number of collections in which each of the species has been reported in company with other species. More than one-half the collections yielded only a single species, while the remainder consisted of from two to eight species. None of the species was exclusively solitary; all were found in association with from two (*L. dispar*) to 20 others (*C. crispatus*, *S. papposus*). In the same Table the kind of substrate occupied by each of the species is shown, with the percentage of collections of each species from the different kinds of substrate indicated.

Table III shows that the species may be divided into three groups on the basis of substrate occupied. The first group comprises the first eight species listed (*P. bidens* to *C. crispatus*) which were found predominantly or exclusively on soft

TABLE III. Associations of species and the kinds of bottom on which they were found.

	P. bidens	*H. pellucidus*	*B. vexillifer*	*P. tenuispinus*	*P. tumida*	*I. panopla*	*U. lincki*	*C. crispatus*	*S. papposus*	*L. groenlandica*	*L. furcifer*	*P. militaris*	*H. eschrichti*	*L. polaris*	*L. dispar*	*L. arctica*	*S. endeca*	*S. syrtensis*	*P. pulvillus*	*P. obscurus*	*H. scabrior*	*S. albula*	*P. typicus*	*L. arcticus*	Substrate						
																									Mud	Sand	Mud-sand	Mud-rock	Rock-sand	Rock-gravel	Unknown
P. bidens	–	2	1	2	.	1	1	1	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	100	.	.	.	.	.	.
H. pellucidus	2	–	2	6	3	4	4	5	1	1	2	1	.	.	.	.	.	.	.	.	.	.	.	.	100	.	.	.	.	.	.
B. vexillifer	1	2	–	2	.	1	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	100	.	.	.	.	.	.
P. tenuispinus	2	6	2	–	5	8	10	7	2	1	2	1	1	.	.	.	.	.	.	.	.	.	.	.	83	17	.	.	.	.	.
P. tumida	.	3	.	5	–	6	16	3	2	4	2	.	1	.	.	.	.	.	.	.	.	.	.	.	79	14	.	.	.	7	.
I. panopla	1	4	1	8	6	–	7	7	4	4	2	1	.	.	.	.	.	.	.	.	.	4	1	1	67	.	.	.	14	13	6
U. lincki	1	4	.	10	16	7	–	15	7	9	1	1	2	1	.	.	1	.	.	.	.	.	.	.	65	3	11	8	5	5	3
C. crispatus	1	5	1	7	3	7	15	–	13	8	2	1	4	2	.	.	1	.	1	1	1	2	1	1	60	.	5	20	7	5	3
S. papposus	1	1	.	2	2	4	7	13	–	29	6	8	20	10	.	2	8	3	5	1	6	18	2	.	15	1	7	18	5	42	12
L. groenlandica	.	1	.	1	4	4	9	8	29	–	4	6	17	16	1	2	6	1	1	4	.	26	2	.	17	3	5	15	5	42	13
L. furcifer	.	2	.	2	2	2	1	2	6	4	–	1	1	.	.	.	1	1	.	.	.	3	3	1	18	.	.	18	9	55	.
P. militaris	1	1	1	1	.	1	1	1	8	6	1	–	8	4	.	.	1	2	4	2	3	5	.	.	14	.	5	27	.	45	9
H. eschrichti	.	.	.	1	1	.	2	4	20	17	1	8	–	6	.	.	4	3	7	2	6	8	.	.	17	.	.	21	4	58	.
L. polaris	.	.	.	.	.	.	1	2	10	16	.	4	6	–	.	3	.	.	.	1	1	5	.	.	3	.	.	11	10	58	18
L. dispar	.	.	.	.	.	.	.	.	.	1	.	.	.	.	–	1	.	.	.	.	.	.	.	.	.	.	.	100	.	.	.
L. arctica	.	.	.	.	.	.	.	.	2	2	.	.	.	3	1	–	2	.	.	.	.	.	.	.	.	.	.	20	20	40	20
S. endeca	.	.	.	.	.	.	1	1	8	6	1	1	4	.	.	2	–	1	1	.	1	2	.	.	.	.	.	16	9	50	25
S. syrtensis	.	.	.	.	.	.	.	.	3	1	1	2	3	.	.	.	1	–	1	.	1	1	.	.	.	.	.	20	20	60	.
P. pulvillus	.	.	.	.	.	.	.	1	5	1	.	4	7	.	.	.	1	1	–	.	5	.	.	.	.	.	.	43	28	29	.
P. obscurus	.	.	.	.	.	.	.	1	1	4	.	2	2	1	.	.	.	.	.	–	1	1	.	.	.	20	.	20	.	60	.
H. scabrior	.	.	.	.	.	.	.	1	6	.	.	3	6	1	.	.	1	1	5	1	–	.	.	.	17	.	.	50	16	17	.
S. albula	.	.	.	.	.	4	.	2	18	26	3	5	8	5	.	.	2	1	.	1	.	–	1	1	.	.	10	10	3	46	31
P. typicus	.	.	.	.	.	1	.	1	2	2	3	.	.	.	.	.	.	.	.	.	.	1	–	1	.	.	.	.	.	100	.
L. arcticus	.	.	.	.	.	1	.	1	.	.	1	.	.	.	.	.	.	.	.	.	.	1	1	–	.	.	.	.	.	100	.

bottoms. Those of the second group (*S. papposus* and *L. groenlandica*) occurred abundantly on a wide range of bottom types, from soft to hard. The third group includes the remaining 14 species listed, and comprises species which occurred mainly on hard bottoms.

There are several interesting relationships which can be shown between substrate inhabited and distribution of many of the species. Two of the clearly circumpolar species comprise the second group. *Solaster papposus* and *L. groenlandica* are the most widely distributed over northern waters of all the species considered. The eight species of the predominantly soft-bottom group show generally more restricted areas of occurrence. They are the species of the northernmost islands of the present region. They are the species of the North Atlantic and adjacent Arctic Ocean waters, and (except for *C. crispatus*, the third circumpolar species) are not recorded from the Pacific or from the Bering, south Chukchi, or Beaufort seas. Species belonging to the two groups are those showing the widest distribution in arctic waters.

The 14 predominantly hard-bottom species are either Atlantic or Pacific or Atlantic and Pacific species. They are known only from the eastern or western or both the eastern and western parts of northern North America. None (with the possible exception of *L. polaris*) appears to range across northern North America. This group includes the primarily subarctic-boreal species, and most have only limited occurrence in arctic waters.

Arctic Ocean and Adjacent Waters

Records of the sea stars reported from northern Canada, West and East Greenland, Spitzbergen, Franz Joseph Land, the Barents and Kara seas, northern Siberia, the Chukchi Sea, and northern Alaska are summarized and their occurrence as well in the Pacific, Bering Sea, and eastern North America between Newfoundland and New England given in Table IV.

There are 56 species and three subspecific forms listed. Of these, 51 are recorded from the Atlantic, seven of them also from the Bering Sea, and five from farther south in the Pacific. Sixteen in all are known from the Pacific and 19 from the Bering Sea or immediately to the north of there, 13 of these being reported from Atlantic as well and six from only the Chukchi Sea – western Canadian arctic north of Bering Strait.

Considering the distribution of North American species in the region covered by Table IV, several patterns of distribution are apparent. There are the widely spread circumpolar species ranging from the Arctic Ocean to boreal waters and found in both the Atlantic and Pacific (Fig. 65a). There are the possibly circumpolar species found primarily in arctic waters adjacent to the Atlantic and off Siberia, but not in the Pacific or off north Alaska (Fig. 65b), the species of the North Atlantic subarctic, absent from the Arctic Ocean proper and from the Pacific (Fig. 65c), the species of the Atlantic subarctic and the Bering Sea and North Pacific, apparently absent from the Arctic Ocean proper (Fig. 65d), the

TABLE IV. Distribution of arctic sea stars.

Species	North Atlantic	North Canada	Nfld.–New England	NW Greenland	SW Greenland	SE Greenland	NE Greenland	Spitzbergen	Barents Sea	Franz Joseph Land	Kara Sea	Laptev Sea	East Siberian Sea	Chukchi Sea	North Alaska	Bering Sea	North Pacific	Circumpolar
Ctenodiscus crispatus (Retzius)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	.	+	+	+
Porcellanaster coerulus W. Thomson	+	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Leptychaster arcticus (M. Sars)	+	+	+	.	+	.	.	.	+	.	.	.	.	.	.	+	+	.
Psilaster andromeda (Müller & Troschel)	+	.	+	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.
Astropecten irregularis (Linck)	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Bathybiaster vexillifer W. Thomson	+	+	.	+	+	.	+	+	+	.	.	+	.	.	.	.	.	.
Pontaster tenuispinus (Düben & Koren)	+	+	+	+	+	.	+	+	+	+	+	+	+	.	.	.	.	.
Ceremaster granularis (Retzius)	+	.	+	.	.	+	.	.	+	.	.	.	.	.	.	+	.	.
Pseudarchaster pareli (Düben & Koren)	+	.	+	.	+	.	.	.	+	.	.	.	.	.	.	+	+	.
Hippasteria phrygiana (Parelius)	+	.	+	+	+	+	.	.	+	.	.	.	.	.	.	.	.	.
Poraniomorpha hispida (M. Sars)	+	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.
P. tumida (Stuxberg)	+	+	.	+	+	.	+	+	+	+	+	+	+	.	.	.	.	.
P. bidens Mortensen	+	+	.	+	.	.	+	.	.	.	+	.	.	.	.	.	.	.
Tylaster willei Danielssen & Koren	+	.	.	.	.	+	.	+	+	.	+	.	.	.	.	.	.	.
Lophaster furcifer (Duben & Koren)	+	+	+	+	+	.	+	+	+	+	+	+	.	.	.	.	?	?
Solaster endeca (L.)	+	+	+	.	+	.	.	+	+	+	.	.	.	.	+	+	+	.
S. syrtensis Verrill	+	+	+	+	.	+	+	+	+	.	+	+	.	.	.	.	.	.
S. glacialis Danielssen & Koren	+	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.
S. papposus (L.)	+	+	+	+	+	+	+	+	+	+	+	+	+	.	+	+	+	+
S. squamatus Döderlein	+	.	.	+	.	.	+	+	+	.	.	.	.	.	.	.	.	.
S. dawsoni arctica Verrill	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	.
Korethraster hispidus W. Thomson	+	.	.	.	.	.	+	+	+	+	+	.	.	.	.	.	.	.
Diplopteraster multipes M. Sars	+	.	.	+	+	.	.	.	+	.	.	.	.	.	.	+	+	.
Pteraster militaris (O. F. Müller)	+	+	+	+	+	.	+	+	+	+	+	+	+	+	.	+	+	?
P. pulvillus M. Sars	+	+	+	.	+	.	+	+	+	+	+	+	+	.	.	+	+	.
P. hastatus Mortensen	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
P. obscurus (Perrier)	+	+	+	+	.	.	+	+	+	+	+	.	.	+	.	+	+	.
Hymenaster pellucidus W. Thomson	+	+	.	+	.	.	+	+	+	+	+	+	+	.	.	.	.	.
Henricia sanguinolenta (O. F. Müller)	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
H. tumida Verrill	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	.
H. knipowitschi Diakonov	+	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.

(*Continued*)

TABLE IV Distribution of arctic sea stars. — (*Concluded*)

Species	North Atlantic	North Canada	Nfld.–New England	NW Greenland	SW Greenland	SE Greenland	NE Greenland	Spitzbergen	Barents Sea	Franz Joseph Land	Kara Sea	Laptev Sea	East Siberian Sea	Chukchi Sea	North Alaska	Bering Sea	North Pacific	Circumpolar
H. knipowitschi karika Diak.	.	.	.	.	.	.	.	+	.	.	+	.	+	.	.	.	.	.
H. scabrior (Mikhailovskij)	+	+	+	.	+	+	+	+	+	+	+	+	.	.	.	.	.	.
H. eschrichti (Müller & Troschel)	+	+	+	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.
H. eschrichti laevior (Mikh.)	+	.	.	+	.	+	+	+	+	.	+	.	.	.	.	.	.	.
H. arctica Verrill	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.
H. skorikovi Diakonov	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
H. solida Diakonov	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
H. derjugini Diakonov	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.
Odinia semicoronata Perrier	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Pedicellaster typicus M. Sars	+	+	+	+	+	.	+	+	+	.	+	.	.	.	.	.	.	.
Urasterias lincki (Müller & Troschel)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	.	.	.	?
Icasterias panopla (Stuxberg)	+	+	.	+	+	.	+	+	+	+	+	+	.	.	.	.	.	.
Marthasterias glacialis (L.)	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Stephanasterias albula (Stimpson)	+	+	+	+	+	+	+	+	+	.	.	.	.	.	.	+	+	.
Asterias vulgaris Verrill	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
A. rubens L.	+	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.
Leptasterias mulleri (M. Sars)	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
L. hyperborea (D. & K.)	+	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.
L. floccosa (Levinsen)	+	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.
L. floccosa crassa Heding	+	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.
L. arctica (Murdoch)	(?)	+	.	.	.	.	.	.	(?)	.	.	.	.	+	+	+	+	.
L. dispar Verrill	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.
L. degerbølli Heding	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
L. canuti Heding	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
L. clavispina Heding	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
L. tenera (Stimpson)	+	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
L. groenlandica (Steenstrup)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
L. polaris (M. & T.)	+	+	+	+	+	.	+	.	.	.	.	.	.	+	+	+	+	.

species of the North Pacific, Bering Sea, and the western part of northern North America evidently absent from the main body of the Arctic Ocean and the Atlantic (Fig. 65e), and a single species of the North Pacific, north Alaska, north and east Canada, and Greenland, absent from the east Atlantic and the Arctic Ocean (Fig. 65f).

All the Siberian species (none is endemic) are found in the North Atlantic or immediately north of the Atlantic, while none is primarily Pacific. All the northern Canadian species with the exception of two Pacific forms found in the western

arctic are also North Atlantic species. The large region extending from the western Canadian arctic islands eastward to eastern Siberia appears to comprise a single faunistic region. It corresponds in large part to the region occupied by Ekman's (1953) Atlantic–arctic fauna, but extends the region westward from eastern North America to the western arctic islands.

The species of the Chukchi Sea and north Alaska are primarily Pacific forms. None is exclusively Atlantic, and the only Atlantic species which occur there are the few circumpolar ones and those of both the Atlantic and Pacific which do not occur in the waters between. Two of the Pacific species range as far to the east as the western Canadian arctic islands. The region occupied by this group corresponds to the western portion only of Gurjanova's (1951) Chukchi-American province, set up on the basis of amphipod distribution and shown as extending from the west Chukchi Sea to the Northwest Atlantic. While a single sea star species does appear to occupy this range, and a few members of several other animal groups may share a similar distribution pattern (see Nesis, 1962), Gurjanova's Chukchi-American region evidently does not apply in its full extent to the present sea star fauna. Nor, in fact, does it to the amphipods, according to Steele (1961), or to the pycnogonids (Hedgpeth, 1963), the Pacific elements of both groups evidently being limited north of Bering Strait to the Chukchi and south Beaufort seas.

There appear therefore, in summary, to be two major faunal regions occupied by arctic sea stars (Fig. 63), one, Atlantic–arctic, embracing all of northern North America but the western portion, Greenland and the waters east of there to eastern Siberia, the other, Pacific, including the Chukchi and south Beaufort seas and possibly extending to the western Canadian arctic islands.

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REFERENCES

BELL, F. J. 1892. On the character and variations of *Pontaster tenuispinus*. Proc. Zool. Soc. London, 1892: 430–433.

BUSH, K. J. 1884. Catalogue of Mullusca and Echinodermata dredged on the coast of Labrador by the expedition under the direction of Mr. W. A. Stearns, in 1882. Proc. U.S. Nat. Mus., **6**: 236–247.

CLARK, A. H. 1920. The echinoderms of the Canadian Arctic Expedition, 1913-18. Rep. Canadian Arctic Exped., 1913-18, **8**(C): 13 pp.

1922. Results of the Hudson Bay Expedition, 1920. III. The echinoderms. Contr. Canadian Biol., N.S., **1**: 21–25.

1936. Echinoderms collected by Capt. Robert A. Bartlett in the seas about Baffin Island and Greenland. J. Washington Acad. Sci., **26**(7): 294–296.

1937. Biological and oceanographic conditions in Hudson Bay. II. Echinoderms of Hudson Bay. J. Fish. Res. Bd. Canada, **3**(4): 350–357.

1940. Echinoderms from Greenland collected by Capt. Robert A. Bartlett. Proc. U.S. Nat. Mus., **89**(3098): 425–433.

CLARK, A. H., AND G. J. LOCKLEY. 1942. Some echinoderms from northwest Greenland. J. Washington Acad. Sci., **32**(8): 250-251.

CLARK, H. L. 1904. Echinoderms of the Woods Hole region. Bull. U.S. Fish. Comm., **22**: 545–576.

COE, W. R. 1912. Echinoderms of Connecticut. Bull. Connecticut Geol. and Nat. Hist. Surv., **19**: 152 pp.

DANIELSSEN, D. C., AND J. KOREN. 1881. Fra den norske Nordhavsexpedition. Nyt Mag. Naturvid., **26**: 177–194.

1884. Asteroidea. Norwegian North-Atlantic Exped. 1876–78, **4**: 118 pp.

DIAKONOV, A. M. 1950. [Asteroidea of the seas of the U.S.S.R.] Keys to the fauna of the U.S.S.R., **34**: 202 pp. Moscow and Leningrad.

DÖDERLEIN, L. 1900. Die Echinodermen. Zool. Ergebn. einer Untersuchungsfahrt des deutschen Seefischerei-Vereins nach der Bäreninsel und Westspitzbergen, ausgeführt im Sommer 1898 auf S.M.S. "Olga." Wiss. Meeresunters. Abt. Helgoland, **4**: 195–248.

DÜBEN, M. W., AND J. KOREN. 1846. Ofversigt af Skandinaviens Echinodermer. K. Vetensk. Akad. Handl., 1844: 229–328.

DUNBAR, M. J. 1951 Eastern arctic waters. Bull. Fish. Res. Bd. Canada, No. 88, 131 pp.

1953. Arctic and subarctic marine ecology: immediate problems. Arctic, **6**(2): 75–90.

DUNCAN, P. M., AND W. P. SLADEN. 1877. Report on the Echinodermata collected during the Arctic Expedition, 1875–76. Ann. Mag. Nat. Hist., ser. 4, **20**: 447–470.

1878. Report on the Echinodermata collected during the Arctic Expedition 1875–76. *In* Sir G. S. Nares' Narrative of a voyage to the Polar Sea during 1875–76 in H.M.S. "Alert" and "Discovery", vol. 2, pp. 260–282.

1881. A memoir on the Echinodermata of the Arctic Sea to the west of Greenland. London. 82 pp.

EKMAN, S. 1953. Zoogeography of the sea. London. 417 pp.

FISHER, W. K. 1911. Asteroidea of the North Pacific and adjacent waters. Part. I. Bull. U.S. Nat. Mus., 76: 419 pp.

1928. Asteroidea of the North Pacific and adjacent waters. Part II. Ibid., 76, 245 pp.

1930. Asteroidea of the North Pacific and adjacent waters. Part III. Ibid., 76, 356 pp.

FORBES, E. 1852. Notes on animals of the class Echinodermata collected by Dr. Sutherland in Assistance Bay. *In* P. C. Sutherland's Journal of a voyage in Baffin's Bay and Barrow Straits, in the years 1850–1851, pp. ccxiv–ccxvi.

GORBUNOV, G. P. 1932. [On Echinodermata of Franz Joseph Land and the Queen Victoria Sea.] Leningrad, Vsesoĭuznyĭ arkticheskiĭ institut. Trudy, 1932(2): 93–140.

1946. Bottom life of the Novosiberian shoalwaters and the central part of the Arctic Ocean. Dreĭfuĭushchaĭa ekspediĭsiĭa Glavsevmorputi na ledokol'nom parokhode "G. Sedov" 1937-1940. Trudy, 1946(3): 30–138.

GRAINGER, E. H. 1955. Echinoderms of Ungava Bay, Hudson Strait, Frobisher Bay and Cumberland Sound. J. Fish. Res. Bd. Canada, 12(6): 899–916.

1964. Asteroidea of the "Blue Dolphin" expeditions to Labrador. Proc. U.S. Nat. Mus., 114(3478): 31–46.

GRIEG, J. A. 1906. Echinodermen von dem norwegischen Fischereidampfer "Michael Sars" in den Jahren 1900–1903 gesammelt. 3. Asteroidea. Bergens Museum Aarbog, 1906(13): 46–66.

1907. Echinodermata. Rep. Second Norwegian Arctic Exped. in the "Fram" 1898–1902, 13: 28 pp.

1921. Echinodermata from the "Michael Sars" North Atlantic Deep-Sea Expedition 1910. Rep. Sci. Res. "Michael Sars" North Atlantic Deep-Sea Exped. 1910, 3(2): 44 pp.

1928. Echinodermata from the Siberian Arctic Ocean. Norwegian North Polar Exped. with the "Maud" 1918–1925. Scientific Results, 5(4): 16 pp.

1935. Some echinoderms from Franz Joseph Land, Victoriaøya and Hopen collected by the Norwegian scientific expedition 1930. Medd. Norges Svalbard -og Ishavs-Undersøkelser, 26: 10 pp.

GURJANOVA, E. F. 1951. [Amphipoda of the seas of the U.S.S.R.] Keys to the fauna of the U.S.S.R., 41: 1029 pp.

HEDGPETH, J. W. 1963. Pycnogonida of the North American arctic. J. Fish. Res. Bd. Canada, 20(5): 1315–1348.

HEDING, S. G. 1935. Echinoderms. Medd. om Grønland, 104(13): 68 pp.

1936. Echinoderms. The Thule Expedition to S. E. Greenland 1931–33. Ibid., 108(1): 34 pp.

HOFSTEN, N. VON. 1915. Die Echinodermen des Eisfjords. K. Svenska Vet. -Akad. Handl., 54(2): 282 pp.

KALISCHEVSKIĬ, M. T. 1907. Zur Kenntnis der Echinodermenfauna des sibirischen Eismeeres. Mem. Acad. Sci. U.S.S.R., Ser. 8, 18(4): 67 pp.

KINDLE, E. M., AND E. J. WHITTAKER. 1918. Bathymetric check-list of the marine invertebrates of eastern Canada, with an index to Whiteaves' catalogue. Contr. Canadian Biol. for 1917–1918, pp. 229–294.

KOEHLER, R. 1909. Echinoderms provenant des Campagnes du yacht "Princesse Alice" (Astéries, Ophiures, Echinides et Crinoides). Rés. Camp. Scient. Prince de Monaco, Fasc., 34: 317 pp.

LEVINSEN, G. M. R. 1887. Kara-havets Echinodermata. *In* C. F. Lutken's Dijmphnatogtets zoologisk-botaniske udbytte, pp. 381–418.

LINNAEUS, CARL. 1758. Systema naturae. 10th ed.

LUDWIG, H. 1900. Arktische Seesterne. Fauna Arctica, 1: 445–502.

MACGINITIE, G. E. 1955. Distribution and ecology of the marine invertebrates of Point Barrow, Alaska. Smithsonian Misc. Coll., 128(9): 201 pp.

MIKHAĬLOVSKIĬ, M. N. 1903. Zoologische Ergebnisse der Russischen Expedition nach Spitzbergen. Echinodermen. Acad. Sci. U.S.S.R., Zool. Mus., 7: 460–546.

MORTENSEN, TH. 1903. Echinoderms from East Greenland. Medd. om Grønland, 29: 63–89.

1910. Report on the echinoderms collected by the Danmark-Exped. at North-east Greenland. Ibid., 45: 237–302.

1913. Echinodermer. Ibid., 23: 299–379.

1927. Handbook of the echinoderms of the British Isles. Oxford University Press. 471 pp.

1932. Echinoderms. The Godthaab Expedition 1928. Medd. om Grønland, 79(2): 62 pp.

MÜLLER, O. F. 1776. Zoologie Danicae Prodromus.

MÜLLER, J., AND F. H. TROSCHEL. 1842. System der Asteriden. 134 pp.

MURDOCH, J. 1885. Marine invertebrates (exclusive of mollusks). International Polar Expedition, 1882–1883. Report of the International Polar Expedition to Point Barrow, Alaska, pp. 136–176.

NESIS, K. N. 1962. [Pacific elements in northwestern Atlantic benthos.] Soviet Fisheries Investigations in northwestern Atlantic. Moscow. 375 pp.

PACKARD, A. S. 1863. A list of animals dredged near Caribou Island, southern Labrador, during July and August, 1860. Canadian Nat. and Geol., 8: 401–429.

1867. Observations on the glacial phenomena of Labrador and Maine, with a review of the recent invertebrate fauna of Labrador. Mem. Boston Soc. Nat. Hist., 1: 210–303.

PERRIER, J. O. E. 1896. Contribution à l'étude des stellérides de l'Atlantique Nord. Rés. Camp. Scient. Prince de Monaco, 11: 73 pp.

PFEFFER, G. J. 1886. Mollusken, Krebse und Echinodermen von Cumberland-Sund nach der Ausbeute der deutschen Nord-expedition 1882 und 1883. Jahrbuch der Hamburgischen wissenschaftlichen Anstalten, 1886(3): 23–50.

RANKIN, W. M. 1901. Echinoderms collected off the west coast of Greenland by the Princeton Arctic Expedition of 1899. Proc. Acad. Nat. Sci. Philadelphia, 53: 169–181.

RASMUSSEN, B. N. 1965. On the taxonomy and biology of the North Atlantic species of the asteroid genus *Henricia* Gray. Medd. fra Danmarks Fiskeri- og Havunders., N.S., 4(7): 157–213.

RETZIUS, A. J. 1805. Dissertatio sistens species cognitas Asterarium, 37 pp.

SABINE, E. 1824. Marine invertebrate animals. *In* Supplement to the Appendix of Captain Parry's voyage for the discovery of a north-west passage, in the years 1819–20, pp. ccxix–ccxxxix. London.

SARS, M. 1846. Fauna littoralis Norvegiae. Christiania, 94 pp.

1851. Beretning om en i sommeren 1849 foretagen zoologisk reise i Lofoten og Finmarken. Nytt magasin for naturvid., 6: 121–211.

1861. Oversigt at Norges Echinodermer. Christiania, 160 pp.

1877. New echinoderms. *In* J. Koren's and D. C. Danielssen's Fauna littoralis Norvegiae, pt. 3, pp. 49–75.

SHORYGIN, A. A. 1926. [Echinoderms of the White Sea.] Morskoĭ nauchyĭ institut. Trudy, 2(1): 59 pp.

1928. [The echinoderms of the Barents Sea.] Morskoi nauchyi institut. Trudy, 3(4): 128 pp.

1948. [The Echinodermata.] *In* Keys to the fauna and flora of the northern seas of the U.S.S.R., pp. 465–495. Moscow.

STEELE, D. H. 1961. Studies on the marine Amphipoda of eastern and northeastern Canada. McGill University Thesis, Montreal. 350 pp.

STEENSTRUP, J. J. S. 1857. Om de ved Grønland forekommende Asteracanthion-Arter. Forh. Skandinaviske Naturf., 7: 228–232.

STIMPSON, W. 1853. Synopsis of the marine Invertebrata of Grand Manan. Smithsonian Contrib., 6: 67 pp.

1862. On new genera and species of starfishes of the family Pycnopodidae. Proc. Boston Soc. Nat. Hist., 8: 261–273.

STUXBERG, A. 1878. Echinodermer från Novaja Semljashef. Öfversigt af K. Vetensk. Akad. Förhandl., 1878(3): 27–40.

THOMSON, WYVILLE. 1873. The depths of the sea. London. 527 pp.

VERRILL, A. E. 1879. Radiates. Contributions to the natural history of arctic America, made in connection with the Howgate Polar Expedition, 1877–78. Bull. U.S. Nat. Mus., 15:151–153.

1894. Descriptions of new species of starfishes and ophiurans. Proc. U.S. Nat. Mus., 17: 245–297.

1914. Monograph of the shallow-water starfishes of the north Pacific coast from the Arctic Ocean to California. Harriman Alaska Ser., Smithsonian Institution, 14: 408 pp.

WALKER, D. 1862. Notes on the zoology of the last arctic expedition under Captain Sir F. L. M'Clintock. J. Royal Dublin Soc., 3: 61–77.

WHITEAVES, J. F. 1884. List of the marine invertebrates from Hudson's Strait. Appendix 4 of Robert Bell's Observations on the geology, mineralogy, zoology and botany of the Labrador coast, Hudson's Strait and Bay. Rep. Prog. Geol. Surv. Canada for 1882–83–84, pp. 58DD–60DD.

WHITEAVES, J. F. 1901. Catalogue of the marine Invertebrata of eastern Canada. Geol. Surv. Canada, 271 pp. Ottawa.

GLOSSARY OF TERMS

Aboral surface. The top (dorsal) surface on the disc and of the rays over the carinal and dorsolateral plates.

Adambulacral plates. Form the outer margins of the ambulacral grooves. Bear adambulacral spines (Fig. 17, 42, 59, 66).

Ambulacral groove. Longitudinal trench along the middle of the oral (lower) surface of the rays, containing tube-feet (Fig. 42).

Ampulla. A bulbous sac forming the proximal end of a tube-foot structure, usually single; sometimes bilobed and appearing as double.

Carinal plates. Found along approximately the middle line of the aboral surface of the rays (Fig. 33, 37, 38, 66).

Cribiform organ. A groove between adjacent marginal plates, containing thin vertical plates (in *Ctenodiscus*) or vertical rows of papillae (Fig. 4).

Disc. Central portion or "body" of the sea star from which rays radiate.

Dorsolateral plates. Between the carinal and supramarginal plates on the rays (Fig. 33, 35, 66).

Inframarginal plates. The lower row of marginal plates along the lateral surface of the rays (Fig. 4, 5, 33, 66).

Intermarginal plates. The intermediate row of marginal plates along the lateral surface of the rays (Fig. 66).

Interradius. Surface of the disc between the bases of adjacent rays (Fig. 18, 19, 55).

Lateral surface. The surface of the rays over the supramarginal, intermarginal, and inframarginal plates.

Marginal plates. Comprising supramarginals, intermarginals, and inframarginals (Fig. 66).

Nidamental cavity. Brood chamber, formed beneath the supradorsal membrane.

Oral plates. A series of plates encircling the mouth opening (Fig. 18, 55).

Oral surface. The bottom (ventral) surface of the disc and of the rays beneath the adambulacral and ventrolateral plates.

Papula. Soft, retractile projection, found in the papular areas, respiratory in function.

Papular area. Fleshy area of the body wall visible between skeletal plate rows (Fig. 15, 16, 33, 35).

Paxilliform plate. Skeletal plate with attached upright column topped by spines or tubercles, the latter often moveable (Fig. 9–11).

Pedicel. Solid upright column of a paxilliform plate (Fig. 9–11).

Pedicellaria. A structure of two or more specialized calcareous projections (jaws or simply spines) often opposed to form pincer organs, either straight or crossed.

R:r. Ratio of total radius (disc plus rays) to disc radius.

Ray. One of the (most frequently five) primary projections radiating from the disc; arm.

Sucking disc. Flattened terminal expansion of a tube-foot.

Supradorsal membrane. Soft covering over the aboral surface, supported by the tips of aboral spines and enclosing a cavity between the aboral plates and the membrane.

Supramarginal plates. The upper row of marginal plates along the lateral surface of the rays (Fig. 4, 5, 33, 66).

Tube-foot. Soft projection, usually in two or four longitudinal rows, in the ambulacral groove, with or without terminal sucking discs, locomotory in function.

Ventrolateral membrane. A thin membrane in the Pterasteridae joining the outermost adambulacral spines of each row, and running longitudinally along the side of the ray (Fig. 12, 54).

Ventrolateral plates. Between the inframarginal and adambulacral plates on the rays (Fig. 66).

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Fisheries Research Board of Canada

No. 68 (Second edition). Fishes of the Pacific coast of Canada. By W. A. Clemens and G. V. Wilby. (1961, 443 p., $6.50.)

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